MECHANICAL DENTISTRY

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A PRACTICAL TREATISE ON THE CONSTRUCTION
OF THE VARIOUS KINDS OF

ARTIFICIAL DENTURES

COMPRISING ALSO USEFUL FORMULÆ, TABLES, AND RECEIPTS
FOR GOLD PLATE, CLASPS, SOLDERS
ETC. ETC. ETC.

By CHARLES HUNTER
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Capio Lumen

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PREFACE.

In introducing the present work to the notice of the dental profession, I may say that my design has been to make it a specially practical one. It is written after an experience of nearly twenty years as a mechanical dentist, and contains, besides the results of that experience, much that has been derived from the practical knowledge of others. I hope therefore that I have been enabled in the following pages to give a clear and accurate account of the actual methods adopted by competent workmen, in the construction of the various forms of artificial dentures.

At page 216 and following pages will be found formulæ, tables, and receipts, which have been carefully collected from various trustworthy

sources, and which, being of direct interest to the dentist, will, I hope, further add to the practical character of the work.

To Dr. Richardson's valuable treatise I have been indebted for the account given at page 193 of Dr. Kingsley's method of constructing artificial palates and for the illustrations connected with that subject.

I have to thank, also, the Messrs. Claudius Ash and Sons, who have kindly granted the use of their wood-blocks for many of the illustrations.

C. H.

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MECHANICAL DENTISTRY.

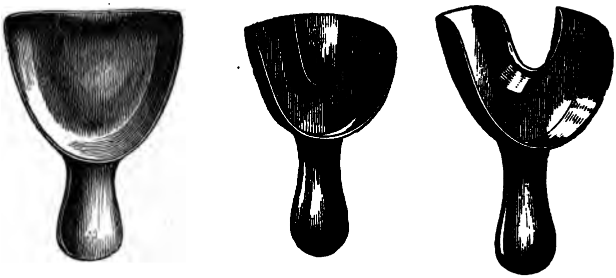
CHAPTER I.

IMPRESSIONS AND PLASTER MODELS.

THE method of practice adopted by the earlier dentists in the construction of artificial teeth was, as may be supposed, very different and much less satisfactory than that which is pursued at the present day. Measurements by means of compasses were first taken of those parts of the jaw for which the artificial teeth were required, and by the indications thus obtained a piece of bone was cut into an approximate adaptation to the space to be filled; the natural gums and teeth were then coloured—as we would colour the plaster model now—in order that fine fitting might be accomplished. Such was the method adopted by Fauchard, and explained in his work published in 1728; and it was not till many years afterwards that the practice of measuring was superseded by that of obtaining an impression of the jaw by means of softened beeswax. At first the piece of wax was held by the fingers and pressed by them into the form of the gum; but it was afterwards discovered that when the soft material was placed in a metal tray of such shape

as freely enclosed the parts of which an impression was desired, and pressed by means of this tray into the shape of the jaw, much more satisfactory results were obtained. Wax as an impression material is now seldom used, composition (Godiva, or Stent) or plaster of Paris being now almost invariably employed for that purpose.

Impression Trays.—The ordinary trays or frames in which the material is placed when an impression of the mouth is taken are made of Britannia-metal, porcelain, German silver, and sometimes

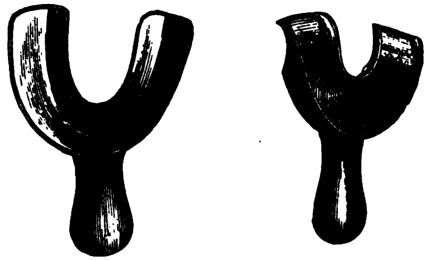


Figs. 1, 2, and 3. Complete Upper Impression Trays.

silver and vulcanite. Those most generally employed are made of Britannia-metal. For complete upper or suction cases trays similar to those shown in Figs. 1 and 2 are used; while for uppers which are not designed for suction—that is, those in which it is not intended to cover the palate with the gold or vulcanite "base" plate—the tray represented by Fig. 3 may be employed.

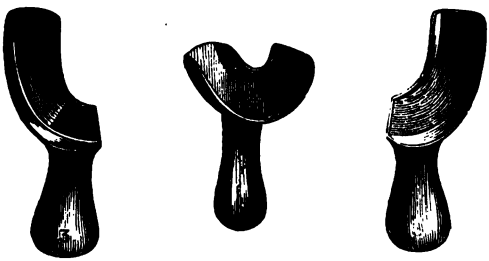
For edentulous lower jaws, and for lowers in which the front six or eight natural teeth remain, such trays as Figs. 4 and 5 respectively are used.

When only a small partial impression of the jaw is required—as is often the case when a substitute consisting of a small number of teeth is to be provided—the tray represented in Fig. 7 is used if the



Figs. 4 and 5. Complete Lower Impression Trays.

deficiency occurs in the front of the mouth, and those represented in Figs. 6 and 8 are employed if the substitute is required for either side. The



Figs. 6, 7, and 8. Partial Impression Trays.

choice of trays for these partial cases, however, depends not only upon the position of the space to be filled, but also upon the position of the natural teeth which will best support the artificial case in

the mouth; therefore it is frequently necessary to use a large or complete tray in such circumstances, in order that the accurate impression of distant teeth may be obtained.

A selection of at least fifteen impression trays, differing the one from the other in dimensions, is necessary in order that the practitioner may be provided with such as are required in every-day practice. Most dentists, however, have a much larger selection.

For special cases where a good impression cannot be obtained by the ordinary means, trays are sometimes made by the dentist himself in the following way. An impression of the mouth is taken in the manner presently to be described, and a plaster cast made; upon this softened gutta-percha or wax about an eighth thick is pressed, covering both teeth and gums, and extending in all directions as far as the more perfect model may be desired to reach. A zinc die and lead counter are then obtained, and a plate of Britannia-metal or sheet zinc is struck to the full size indicated by the wax covering on the model. A piece of metal is then soft-soldered to the bottom of the tray to serve for a handle. This may be done with the blowpipe flame, touching the joint with the soldering liquid described at page 233. The amount of impression material which should be placed in a struck tray is of course very small compared with what is required for the ordinary kind. The material, in fact, should be in the form of a layer but little thicker than the covering upon the model. By this means very accurate impressions may be obtained in

difficult cases with the composition. A struck tray is never employed when plaster of Paris is the impression material; in these circumstances, if it be desirable to use a special tray, one may be made from gutta-percha which has been pressed into shape on the plaster model, a piece of iron wire bent into suitable shape being heated and imbedded in the gutta-percha to serve for handle (see pp. 183—196).

Impression Materials.—(*a*) *Wax.* — This substance is frequently adulterated with farina, resin, stearine, &c.; it is therefore necessary to exercise care in its purchase. The following is a simple method of testing its purity: "Pure beeswax becomes kneadable at about 85°, and its behaviour while worked between finger and thumb is characteristic. A piece the size of a pea being worked in the hand till tough with the warmth, then placed upon the thumb and forcibly stroked down with the forefinger, curls up, following the finger, and is marked by it with longitudinal streaks." *

The blocks of wax as purchased should be broken with the sharp blow of a hammer and chisel, and melted in a pipkin (over boiling water); the wax is then poured upon plates which have been slightly oiled. The discs obtained in this manner can be readily softened, and each of them should contain sufficient material for an upper or lower complete model. Wax may be softened by dry heat or by warm water. By using the former, the working qualities are retained longer in the wax than when water is used. Whichever method be

* Barnard Proctor.

employed, however, careful application of the heat is necessary, so that the material shall be made sufficiently soft without bringing it near the melting point. Wax melts at 190° F., and the heat recommended for the water in which it may be softened is 120° to 130° F. When soft it is kneaded by hand, rolled to shape, and placed in the impression tray—which should be first heated slightly in order to make the wax adhere to it. The impression is then taken, greater force being required in the upward pressure than that required for composition or plaster. "Some practice is necessary," Mr. Harris says, "in knowing the proper quantity of wax to use in the cup; the usual mistake is to take too much." This applies still more when composition or plaster is the impression material; for these being much heavier than wax, there is so much the greater tendency for (in the case of uppers) the material to fall away from the surface to which it is pressed. The wax should be moulded, when placed in the tray, into a rough outline of the mouth to which it is to be applied; this will enable the operator to do with less material and less pressure than would otherwise be necessary.

(*b*) *Gutta-percha.*—This substance is much valued by some dentists, as giving most accurate impressions, and being especially useful for under-cut cases. The general experience seems to be, however, that gutta-percha is not to be depended upon for this purpose, the shrinkage which it undergoes after withdrawal from the mouth being very considerable. To avoid this shrinkage, it has been recommended to leave it till it becomes perfectly

hard before withdrawing; but then it will be found in under-cut cases that it is impossible to *withdraw* the impression. If the dentist should ever experience this, the best plan he can adopt for extracting the tray and material is to soften the latter by means of warm water. Time must be allowed, and as the mouth becomes inured, the temperature of the water given may be increased, until the gutta-percha shall be softened sufficiently for withdrawal. To prepare this substance, heat it in water slightly under boiling point, and dry it before placing in the warmed impression tray.

(*c*) *Godiva, or Stent, Composition.*—By means of this composition impressions may be obtained with much more accuracy than with wax, though with less accuracy than with plaster. It does not, however, demand so much from both operator and patient as the latter substance, and its inferiority is perhaps so little as to make it preferable in many cases where a plaster model is not easily obtained. Therefore we find the composition used generally for partial cases, while for edentulous uppers or lowers plaster is employed. It is softened in water of a somewhat higher temperature than that required for wax; but the water should never be allowed to reach the boiling point, as over-heating destroys the material. The tray is filled in the manner already described. In taking the impression less force is required than for wax, and the material must be kept in position while setting by preserving a steady pressure upon the tray. When the composition has become sufficiently hard, the impression is withdrawn from

the mouth, and cold water should be allowed to flow over it.

(*d*) *Plaster of Paris.*—This is generally recognised to be the material which gives the most perfect impression of the mouth. The plaster for this purpose should be new and of the best quality. It must be carefully mixed, and this should be done in or as near the operating-room as possible. It is generally found necessary to mix with the water, before adding the plaster, a small quantity of salt or other substance which will accelerate the setting. The quantity of this setting-mixture to be used altogether depends upon the condition of the plaster at the time of mixing. New plaster, for instance, requires more "hastening" than that which has been some time in use. Where there is any doubt about the setting-time of plaster, a small quantity should be mixed as a test, and the time noted that it takes to change from the consistence of molasses to the condition when it will *break*. The mixture can then be applied, so as to accelerate up to the desired time.

The proper quantity of water and setting-mixture having been placed in a small basin, the plaster is added in a careful and equal manner until it reaches the surface of the water; it is then mixed thoroughly and filled into the tray. The plaster should be left higher in the centre, so that on introducing it into the mouth it will come first in contact with the palate. When it shows a disposition to retain the form given to it with the knife or spatula, it is in a proper condition for placing in the mouth and taking the impression. Another

guide for this is when the tray can be turned over without spilling the plaster. For very high palates a little plaster is sometimes taken from the basin on the point of the forefinger, and placed directly on that part of the palate just before introducing the tray.

With regard to taking the impression, Mr. Coles says: "The great secret of saving your patient any discomfort is just to have the right quantity of plaster in the tray to suit the case, and then with a steady hand place it well back in the mouth before you let it touch the teeth. After this bring the free borders of the back of the tray into contact with the superior part of the palate, and then press upwards from behind forwards until the whole of the tray embraces the dental arch. Adopting this plan secures two points: you prevent the plaster falling backwards and falling upon the base of the tongue to produce retching, and also bring the overplus to the front of the mouth, where it is visible and therefore more manageable. When the plaster that remains in the basin will break with a clean sharp fracture the impression must be removed from the mouth. Air having been let in at the sides by drawing away the cheeks and lips, steady downward pressure must be applied to detach the mould from the teeth and gums. At this part of the process there must be no hesitation on the part of the operator, as every moment the hardness of plaster is increased and the difficulty of safe removal becomes greater." For edentulous and many partial cases the ordinary tray, filled in the manner described, will give the best results.

Where the teeth standing in the mouth are leaning towards each other, however, or are what is called under-cut, a plaster impression so taken would occasion much trouble, so that it is advisable to provide in a special way for overcoming these difficulties.

We may do this either by altering the arrangement in the tray, so that on withdrawing the impression, the plaster will readily break at the difficult points, and in such a manner that it can easily be joined again, or we may make such a temporary change upon the standing teeth themselves as will enable the impression to be readily withdrawn.

The first can be effected in the following manner. Take an impression in Godiva or wax in the usual way, and scoop out this over palate and gums to the depth of at least an eighth of an inch, and freely about the teeth, leaving, however, the border of the impression standing to the breadth of about an eighth of an inch. This forms a shallow box, into which—the surface having been roughened—plaster is filled, the narrow border which has been left across the palate being a guide as to the quantity required, and also serving as a dam to prevent the escape backwards of the plaster. The model is taken in the manner already described for this material, and, when withdrawn, the plaster will readily break at the under-cuts. The pieces are then collected, placed back in position, and fastened with cement at the bench.

Professor Austen advocates another method, but on the same principle: "Take a wax impression

and make a model; in partial cases brush over the teeth of the model one or two layers of thin plaster, to fill up all under-cuts, and to make the plate fit loosely; saturate the model with water and mould over it a gutta-percha cup. It should be on the inside from a $\frac{1}{4}$ to $\frac{1}{8}$ an inch thick, so as to be stiff and unyielding; but on the outside, next the lips, not more than $\frac{1}{8}$ or $\frac{1}{16}$ thick, so as to be slightly elastic and yielding. The whole inside of the cup must be roughened up with a scaler or excavator in such a way that the plaster can take firm hold. In most partial cases the impression must be removed in sections, the inside remaining entire, but the outside and the parts between the teeth coming away separately. In very difficult cases it is necessary to partially cut into the cup, so as to permit its removal in sections with the plaster adherent. These cups have no handle, but are removed by inserting a plugging instrument into a small hole previously made in the back part of the cup where it is thickest."

The other principle upon which these difficulties are overcome is to make such alterations in the mouth itself as will permit the withdrawal of the impression. This is done by first of all drying the parts, and filling in the under-cuts with softened wax or clay; the impression is then taken with an ordinary tray filled with plaster.

Preparation of Impressions previous to casting in Plaster.—Those taken with Godiva or with wax should be thoroughly cooled by running cold water over them before they are worked with; and *all* impressions must be perfectly cleansed from the

saliva or blood which may adhere to them. Blood is generally found upon impressions where the roots have been filed, and if allowed to remain it will rot the plaster it comes into contact with, and thus injure a part of the model it is most important to retain perfect. The surfaces of the composition or wax may be cleansed by using cold water and a camel-hair brush. For plaster impressions hot water may be employed. Teeth standing by themselves must be supported in the plaster model; therefore it is necessary to insert pins into the depressions which indicate their position in the impression material. These pins may be of copper or iron wire, of the thickness used for tube teeth, and should be of varying lengths. Each pin should be about double the length of the tooth it is meant to support. Where the impression of the tooth goes right up to the metal of the tray—as often happens with long incisors—the pin should be bent at one end to a right angle for about an eighth of an inch; the short end is then inserted in the back or face of the tooth, near its apex. For Godiva the wire must be heated slightly before inserting, and held in position until the material hardens round it; for plaster, a hole must be drilled for its reception.

The surface of composition and wax impressions may receive a very thin coating of oil. The surface of those taken with plaster must receive a very thorough and careful coating before casting, or the parting from the model afterwards will not be easily or safely accomplished. Oil may be used for this class of impression, in which case several

coatings must be given. Parting liquids are sold by the manufacturers for this special purpose; and Harris gives the following as suitable parting substances: "1st, a varnish of sandarach, or shellac, or of dilute soluble glass, with a little oil upon the varnished surface when dry; 2nd, by saturating the impression with as much oil as it will take up without standing upon its surface; 3rd, by coating with a dilute soap mixture." The first—varnish—is liable to dull the sharpness of the impression, and is therefore objectionable. Perhaps the most suitable is the soap mixture, carefully applied with a camel-hair pencil.

Casting the Plaster Model.—It is of great importance that, whether for vulcanizing upon or for plate work, we should have what is called a "hard model." The only way known in which we can obtain this is by mixing the plaster thick—that is, with as much plaster to the water as we can make it take up.

None of the substances described as having the power to harden plaster have really any influence in that direction. After a little practice it may be mixed and shaken into the impression in a thicker state than might at first have seemed suitable for that purpose; and if it be made in this way, and the drying be properly done, a strong hard model will be the result. When the plaster has been mixed, the impression is taken in the left hand, and the plaster is introduced (with the knife or spatula) at one end of it—that would be in a full upper on the slope leading down to the last molars; from this the plaster must be made to flow right round and

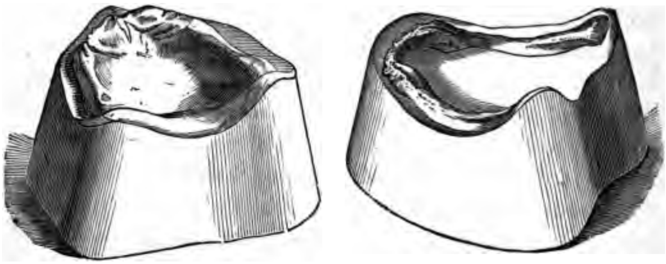
over the impression. This is done by tapping the bottom of the tray upon the bench continuously, while the plaster is being added at the part referred to only. Care must be taken not to strike against the impression material while filling it with plaster; and in the case of the more fragile impressions some kind of cushion should be used for striking the under surface of the tray against. By filling in this way (from one point only of the impression) the air is expelled before the advancing plaster in a harmless and regular manner: if the latter be introduced on the other hand at *different* parts of the impression, it flows together and *encloses* the air, and a more or less false model is the result. When the impression is once covered, the plaster may then be quickly added to a thickness of about a quarter of an inch. If the model is for a vulcanite case no more building is necessary: it is allowed to harden, when the further stages are proceeded with. For a "plate" model, however, it must be built much higher, and this is done whenever the plaster in the basin becomes thick enough to "hold" or retain itself in shape. It is then taken out of the basin, and formed, upon a square of paper or glass placed on the bench, roughly to the height and shape of the model desired. The impression tray is next taken, and, being turned over, its plaster is pressed down into that just built upon the glass, a knife or spatula being used to draw up the one plaster over the other, and also to improve the shape, so far as that can be done while the model is in this soft condition. Only a little practice is required to make this the quickest and

in all respects, the most satisfactory method for casting a model in plaster. The latter must then be allowed to become thoroughly hard before attempting to separate it from the impression material.

The separation of wax from the plaster model may be accomplished by dry heat or by warm water. If the former be employed the heat should be allowed to come to the wax through the plaster; a moderately hot iron plate, if the model be laid upon it, will answer the purpose well. In either case over-heat must be avoided, and the wax only softened so far that in drawing it from the model the plaster teeth will not be in danger of breaking. For composition hot water only should be used. The model, being placed tray downwards in the water, should remain, where there are teeth standing at least, until the impression material has become soft throughout, before separating. Where plaster has been employed for the impression very great care must be taken. If colouring matter has been mixed with the impression plaster the line of separation between it and the model will be more readily observed. The separation, in many cases, is effected by gently tapping the tray and enclosing border of plaster; generally, however, it is necessary to *prise* the impression plaster away from the other. Before doing this it may be an assistance to heat the parts. Mr. Coles says they "should be placed in a basin of boiling water and allowed to remain for two or three minutes. The heat produces expansion of the plaster, and the one portion (the impression) having been mixed earlier than

the model this expansion is unequal and thus starts the division of the impression."

Supposing the model to be for a plate "base," it must then be pared with the knife, so that it shall part easily from the sand in the process of sand-moulding. For this purpose it is not only necessary to cut the sides with such a slope that will enable the model easily to drop from the sand, but such parts as are not intended to be covered by the plate, and are likely to grip in the sand, must be filled either *now* with plaster or afterwards (after



Figs. 9 and 10. Upper and Lower Plaster Models pared into shape.

waxing the model) with wax. The accompanying figures represent an upper and lower model pared into shape.

Some dentists would now at once proceed with the sand moulding; but the usual practice is to "dry" the model at this stage and wax or varnish its surface. For this purpose it should be placed at the fire in such a position as will insure the heat being *gradually* raised to a point beyond what can be easily borne by the hand. The model is then dipped, by means of a stout thread tied round it,

into the mixture, which by this time should be melted and *hot.**

If both are in proper condition the mixture will at once boil up over the model, which may remain thus covered for about a minute. It is then withdrawn, and, the adhering mixture having been drained off, is laid aside to cool. From a quarter of an hour to an hour may be given for "drying" a model. But it should be remembered that though by under-drying the hardest possible model is not obtained, over-drying is accompanied by much more serious results; for it will be found that a model which has been allowed to remain for a considerable time close to a strong fire, and then waxed, is quite unfit for use. Therefore it is necessary to attend carefully to the heating of the model; and it would perhaps be better to say "wax the model when it is hot" rather than "when it is dry."

* The mixture in which models are "boiled" is generally composed of from one to two parts resin to one part wax; sometimes stearine is used for this purpose.

CHAPTER II.

CASTING METAL MODELS.—SAND MOULDING.—ZINC.—LEAD.

Moulding Sand.—The sand employed by dentists for this purpose is the same as that used by brass-founders.

It must be made sufficiently damp with water to give the necessary cohesion to its particles, and that which is to come in contact with the model must be fine grained in order to take a sufficiently sharp impression of its surface. Sand which when closed in the hand takes a good impression of its lines, and breaks with a clean fracture, may be said to be in proper condition for moulding.

But in preparing this material, and in the subsequent operations, it is necessary to remember that the conditions which are most favourable to obtaining a good impression in the sand—viz. dampness, fineness of the grain, and tight "ramming"—are most unfavourable for the reception of the melted zinc which is to be poured into it. So that with over-damp and tightly consolidated sand the zinc will boil and an imperfect model will certainly result. Or if only the necessary dampness has been given,

still, if the sand be tightly packed, there will be the same unsatisfactory result.

The explanation is, that when the melted metal comes in contact with the sand steam is immediately formed, which, if the latter be loosely packed, will escape harmlessly through the pores; but if, on the other hand, the sand be solid, then the steam cannot escape in that way, but struggles through the metal, causing it to "boil," and a false model is generally the result. The sand which is to come in contact with the model may be fine grained, but the flask or ring should be filled up with a coarser kind.

Casting Rings or Flasks.—These are sometimes in the form of a square wooden frame; but generally iron rings are used for this purpose, of very simple construction, being merely a hoop of cast-iron, greater in height and circumference than the model to be cast in it, so that sufficient space may be left between the model and iron in all directions for the sand in which the former is to be enclosed.

The casting ring is placed upon the bench, and the model, after being brushed with parting powder (lycopodium, or French chalk), is placed in the centre of the ring. The fine sand is now dropped over the palate, &c., and this is followed by the coarser kind, sufficient pressure being used to carry the sand into all the irregularities of the model. The ring is now filled up with the coarser sand, and it must not be "rammed" solid, but only sufficiently tight to prevent it from giving way in the subsequent handling. A knife should be drawn across the superior border of the iron ring, to give the

sand a perfectly level surface. The mould is now lifted perpendicularly by the left hand a few inches from the bench, and a few taps over the bottom surface of the model with a riveting hammer will suffice to disengage it from the sand.

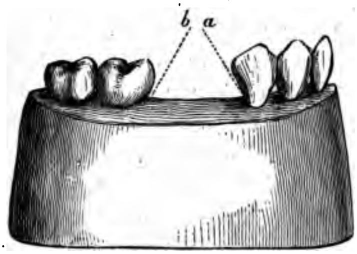
Another method of taking the model from the sand may be adopted. After filling the ring and levelling the surface, the mould is turned over, so that this surface shall be next the bench (which must be clear of sand and flat). The model is then gently tapped over the surface with the hammer, and lifted out of the sand as it becomes loosened, either by means of a pointed tool or screw sunk in the plaster, or by inserting the thumb and forefinger just enough to grasp the model at opposite points; while it is so held with the left hand the hammer is used in the right. This method of bringing away the model we decidedly prefer for the following reasons. When this plan is adopted, portions of the sand impression which may become detached still remain in the mould, and can, with careful treatment, be pushed into position again; but when the model is dropped out, as in the first method, the detached sand falls with it, and cannot be replaced. Again, it is possible to humour a model when lifting it out, so as to preserve an under-cut, which would break away if the other method were employed. For example, an edentulous upper, with an under-cut in front, may often be withdrawn in this way without injury, if the sand be first cut from the back wall of the model to allow for the necessary movement. Where it has been considered necessary to use fine sand tightly consolidated, an escape may

be provided for the steam by piercing the sand with a broach over the surfaces not required for the fitting of the plate; for example, the palate may be treated in this way when only a narrow gold plate is to be fitted to the model.

The majority of models may be obtained by the methods just described; but others are met with presenting difficulties not so easily overcome. Partial cases, for instance, where the teeth, from their shape and inclination, make it impossible to withdraw the model without destroying the impression; and edentulous cases also, where undercuts extend along both sides of the model. In the former—partial cases—the difficulties are got rid of, when the teeth causing the trouble are to be *clasped*, by removing the complicating teeth from the model previous to taking the sand impression. In order that they may be removed satisfactorily, and so that they may be *replaced* perfectly, it is necessary to have this point in view when inserting the iron or copper pins into the impression material before casting the model in plaster. The pins should be straight and slightly bevelled, and the *thicker* end inserted in the impression material. Before taking the model in sand, the teeth to be clasped and likely to cause difficulty are cut round their necks with the fine bench saw, but only so far that by a slight rotary pressure a clean fracture across the neck will take place, and the tooth and *pin* will leave the model together. An otherwise impossible impression may now be taken with ease; and the teeth may be returned afterwards to perfect position, a little cement from a hot knife being used to

fix them. It will be observed that if the pins had not been bevelled as described, they would probably have remained standing in the model when the teeth were removed.

Where this method cannot be adopted the under-cuts may, in many instances, be filled out with wax to simplify the sand moulding; for there is a considerable number of cases of this description in which a perfect fitting of the plate into the under-cuts is undesirable; Fig. 11 shows such a case, where it would be impossible to insert in the mouth

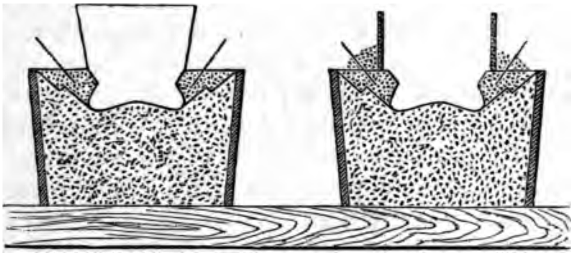


Figs. 11 and 12. Models showing peculiar difficulties with respect to casting in Sand.

a plate fitting perfectly to the under-cuts here indicated. In other cases again we might make an addition, for the purpose of facilitating the moulding, which may easily be taken away with file or punch from the zinc cast.

By the means already noticed we are enabled to succeed with all but a few cases of special difficulty, and these include edentulous uppers, where the under-cut extends along the outside of the alveolar ridge on both sides of the jaw. The figure shows a section of a model with these under-cuts at A and B.

In such a case we fill a casting ring loosely with sand, and, when filled above the level of the ring, consolidate the surface slightly with the hand. Now take the plaster model and press it perpendicularly down upon the sand until the impression is buried about an inch, when the sand is pressed compactly between the ring and model. A knife is now used to cut a wedge-shaped block from each side, which will thus leave the under-cut parts entirely exposed, and the model is withdrawn. The surface of the cut sand may now be more carefully shaped



Figs. 13 and 14. New method of casting in difficult cases.

and made as *smooth* as possible. Parting material* is then shaken over these prepared surfaces, and the model, which should also be brushed with chalk or lycopodium where it comes into contact with the new sand, carefully replaced. The prepared spaces on each side are now filled with the finest sand, made thoroughly cohesive and consolidated as well as the circumstances will permit (Fig. 13). While packing these side blocks, one end of a short length of binding wire may be left imbedded, by

* The best parting substance for this work is sand which has been dried by heat and reduced to fine powder.

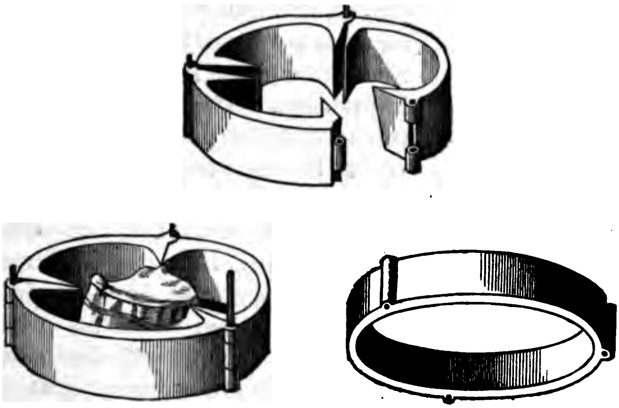
which they can readily be moved. The model is now slightly tapped, the cores drawn gently aside, only sufficient to allow the model to pass, and the latter is withdrawn. The cores are returned to the exact position, and the zinc might now be poured; but before doing so we must provide means for obtaining a thicker and stronger zinc. For this purpose an iron shape, represented in section in Fig. 14, must be placed lightly upon the sand, which will give its own form to the metal—an upper part of a vulcanite flask for instance comes very near the shape required. Some fresh sand should be gently placed against the shape all round, in case the metal should escape.

This method of taking difficult impressions by means of cores has been described with reference to edentulous cases only; but of course the same system may be adopted with partial cases presenting similar complications.

By one or other of the methods explained a means will, we think, be found for casting models of every description, and that in the readiest and simplest manner. A moulding flask, however, was introduced several years ago by Dr. Hayes, which was specially designed to overcome the difficulties met with in the class of models we have last described. This flask has not, however, come into general use; the complication of parts may partly explain why it has never become a favourite with practical dentists, but besides this it may be said that though the theory upon which it is constructed is correct, the theory is one which cannot very easily be perfectly carried out in practice.

Figures 15 and 16 represent the lower section of this flask. In the former figure the joints are opened slightly to show the movement of which it is capable; in the latter the same section is seen closed with a model in the centre placed ready for sand casting. Fig. 17 represents the upper section of the flask.

To cast by means of this arrangement, the lower



Figs. 15, 16, and 17. Dr. Hayes's Casting Flask.

section must be closed and the joint secured by a pin, and the model placed as shown in Fig. 16. Should there exist between the sides of the model, when so placed, and the flanges, or projecting points of the flask, a considerable space, slips of paper may be placed in the joints which shall reach to the sides of the model; this will facilitate the parting of the sand which afterwards takes place. Now fill in the sand around the model until

the most prominent line of the gum is reached—that is, until the under-cuts are enclosed by the sand—and smooth the sand surface. It is then necessary to cover the latter and the exposed surface of the model with a film of pulverized charcoal; join the upper section of the flask to the lower, and complete the moulding by filling with sand. When this has been done the two sections are separated; the pin securing the joint of the lower is then withdrawn, and that part is opened so far as to permit of the model being removed without injuring the sand impression. After the removal of the model the parts of the flask must be accurately readjusted and secured; the metal is then poured in the usual manner. The greatest care must be observed in separating and in reclosing the parts when working with this flask, for it will be seen that unless the readjustment is perfectly accurate most unsatisfactory results will be obtained.

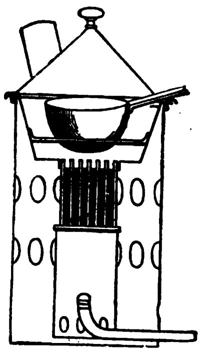


Fig. 18. Fletcher's Stove for Zinc and Lead melting.

Zinc.—The metal for models and counters may be melted in a gas-stove, in which case a ladle is used (Fig. 18 shows a stove for this purpose, made by Mr. Fletcher, Warrington); or it may be melted on an ordinary fire fitted with a blower, in that case a plumber's pot instead of the ladle should be used, a small ladle being employed to lift the melted metal from the pot and pour it into the mould. Over-heating completely destroys zinc; it should

therefore be carefully attended to while heating, and the mould filled whenever the melting takes place. The small ladle should be heated well before using it for lifting the zinc. Besides preserving the metal in a good working condition, this plan is also, of course, favourable to obtaining a model uninjured by "boiling." After the mould has been filled and the zinc is properly set, the latter is then taken from the sand and cooled. The metal model is now compared with the plaster one, and any defects removed by using the steel punch (Fig. 19) or file.

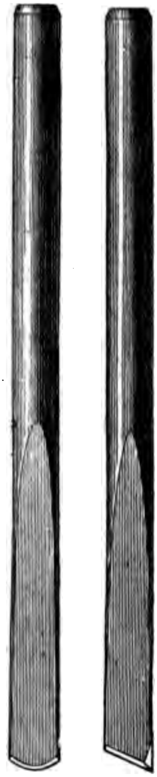


Fig. 19. Punches for dressing Zinc Models.

Lead.—The counter may now be taken in either of two ways. The melted lead may be poured over the zinc model, or the latter may be "let down" into the melted lead.

To obtain the first, the zinc—which must be perfectly dry—is placed upon the bench, and sand is heaped round it and high enough to reach the margin of the impression. The cast-iron ring which is to give shape to the counter is then placed lightly upon the sand, some of which is banked up over its edges to prevent the lead from flowing under the ring and out of the mould. Into this iron shape, the walls of which rise about two inches above the surface of the zinc impression, and are

slightly inclined so as to facilitate parting, the lead is poured.

To obtain a counter by the other method, the lead is melted and poured into a suitable iron shape, and the zinc, held in the hand or by pliers teeth downwards, is imbedded to the extent required, in the melted metal, and held in position until the latter sets. Or the lead having been melted in a ladle, the zinc may at once be sunk in it, while so held, until the impression is sufficiently imbedded. When set, the lead counter is struck from the ladle, and, being of the same shape as the latter, it forms what some consider a most convenient reverse, especially where it is the custom to do much of the striking upon the knee or in the hand. We prefer to make the counter in the manner first described; it need take no more time than the others, and a good one is perhaps obtained with more certainty.

When the metal models have been cooled in water, they may then be separated by striking the zinc on opposite sides with the bench hammer.

The shrinkage of zinc interferes more or less with the perfect fitting of plates, and some dentists have tried what are called "fusible metals," which have much less shrinkage than zinc. There are objections to the use of the fusible metal models, however, of another kind, which render them unsuitable, so that in regular practice zinc is still employed as the best metal from which the die can be made. The following particulars with regard to fusible metals are given by Professor Austen:

"**Type Metal.**—Lead, 5 parts; antimony, 1 part. Fuses at 500°, contraction less than one-half that of zinc, more compressible than the latter, and very brittle.

"Zinc, 4 parts; tin, 1 part. Fuses at a lower heat, contracts less in cooling, and has a less surface-hardness than zinc.

"Tin, 5 parts; antimony, 1 part. Melts at a lower heat than either of the preceding alloys, contracts but slightly in cooling, is harder than tin, and sufficiently cohesive. It is readily oxidized, and should be poured as soon as melted."

Fusible Alloys.—The following tabular view of the more fusible alloys, the respective properties of which are deduced from actual experiments, is given by Professor Austen, in a paper on "Metallic Dies" (*American Journal of Dent. Science*, vol. vi. p. 367). Zinc is introduced into the table for the purpose of comparison.

	Melting point.	Contractility.	Hardness.	Brittleness.
1. Zinc	770°	·01366	·018	5
2. Lead 2, tin 1	440°	·00633	·050	3
3. „ 1, „ 2	340°	·00500	·040	3
4. „ 2, „ 3, antimony 1	420°	·00433	·026	7
5. „ 5, „ 6, „ 1	320°	·00566	·035	6
6. „ 5, „ 6, „ 1 bismuth 3	300°	·00266	·030	9
7. Lead 1, tin 1, bismuth 1	250°	·00066	·042	7
8. „ 5, „ 3, „ 8	200°	·00200	·045	8
9. „ 2, „ 1, „ 3	200°	·00133	·048	7

CHAPTER III.

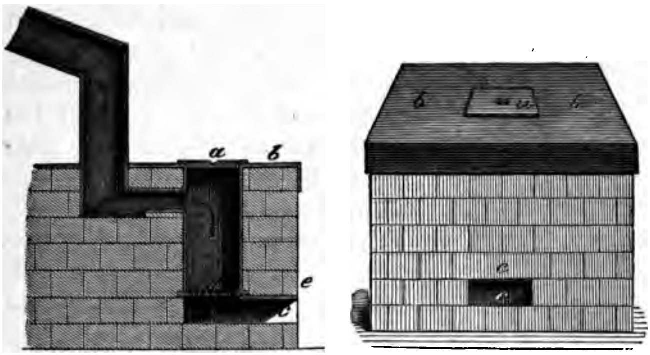
GOLD.—PLATE.—CLASPS.—WIRE.

FINE gold is much too soft to be employed as a "base" plate for artificial teeth; it is therefore necessary to mix with it a certain amount of silver and copper to obtain the hardness required for this purpose.

Four pennyweights of alloy to the ounce of fine gold is sufficient to render the metal suitable for dental purposes; and this is the quality of gold (20-carat) adopted by many eminent dentists for base plates, while they use 18-carat for clasps, &c. The standard favoured by the majority of dentists, however, is 18-carat—6 dwt. alloy to the 18 dwt. of fine gold—for plates, and 16-carat for clasps and wire. It would be more satisfactory if the clasps, &c., were made of the same quality as the main plate, as then we should be able to use solder of a higher quality than is at present possible.

Gold plate and wire, of the various thicknesses and qualities required, may be purchased at the depots; and in practices where there is a constant flow of mechanical work probably that is the most profitable plan to adopt. Where quiet seasons

occur, however, with considerable regularity these may advantageously be turned to account by the dentist preparing his own plate and wire. To accomplish this the following are the chief implements required: furnace, crucibles, rollers, draw-plates. The furnace employed for melting the metal may be the ordinary draught furnace (Figs. 20 and 21), built of brick-work, the chamber in which the fuel and crucible are placed being about 8 inches square



Figs. 20 and 21. Draught Furnace for Gold.

and about 15 inches deep. The sides of this chamber are formed with fire-bricks, and at the bottom is the grate *d* (Fig. 20) which supports the fire; the rest of the work may be done with the ordinary bricks, building up to suitable shape. When this is completed the top forms a flat surface, upon which an iron plate *b* is fixed, which forms a convenient heating surface for many purposes. Or the melting may be accomplished by means of a gas furnace. Of these, the one introduced by Mr. Fletcher, War-

rington (Fig. 22), is best known to dentists, and it is highly spoken of by many. Of crucibles there are two kinds: the clay, and the plumbago or black-lead crucibles; the latter are to be preferred for several reasons. They can be used repeatedly—Mr. Gee says from twenty to fifty times with care—and therefore their original excess of cost over the others disappears. They may be subjected to the greatest and most sudden alterations of temperature without cracking; and, most important of all, their surface, both within and without, may be made very smooth, so that particles of melted metal will not hang about the sides—an advantage not possessed by any other crucibles in the same degree.*

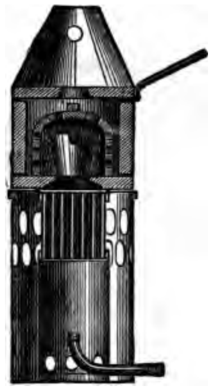


Fig. 22. Gas Furnace for Gold (Fletcher's).

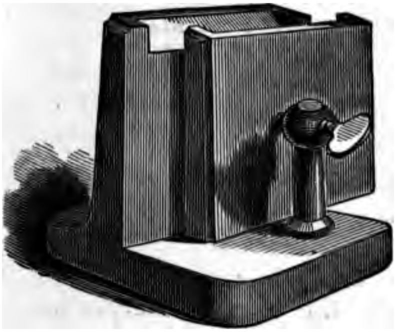
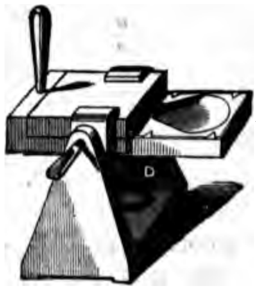
Iron tongs are required for lifting the crucible from the fire, and for pouring the metal into the ingot mould or "skellet."

Fig. 23 shows an ingot-mould of the ordinary kind. For small quantities of gold the arrangement shown in Fig. 24 has been introduced by Mr. Fletcher. Here the gold is melted by the blowpipe flame, when it is made to flow into the mould by turning the latter by means of the handle to a suitable inclination.

Alloying the Gold.—Weighing the alloy for the gold requires strict attention. To prevent the

* Percy's "Metallurgy."

possibility of error, the calculation and weight should be checked by a second person.

Figs. 23 and 24. Ingot Moulds.

With fine gold the amount of alloy required to reduce one ounce to the several carats is as follows :—

	dwts.	grs.	
To the ounce of fine gold add of alloy . .	4	0	= 20 carat.
" " " . .	5	15	= 19 "
" " " . .	6	16	= 18 "
" " " . .	10	0	= 16 "
" " " . .	14	6	= 14 "

It is frequently found most convenient to reduce from gold coin, which, being mixed with the greatest accuracy, can be perfectly relied upon as regards its carat value.

The English sovereign is 22 carats fine, and weighs 5 dwts. $3\frac{171}{623}$ grs.; it is therefore worth for melting exactly its value as coin.

When the sovereign is used, less alloy is of

course required than for fine gold; the proportion required for the several carats is as follows:—

		dwts.	grs.	
To four sovereigns add alloy	. . .	2	1	= 20 carat.
" "	. . .	3	6	= 19 "
" "	. . .	4	12	= 18 "
" "	. . .	7	12	= 16 "
" "	. . .	11	7	= 14 "

Alloy.—For gold plate the alloy used is always silver and copper. The proportion in which these are mixed with the gold influences the latter both as to colour and hardness: copper gives hardness and a red tinge to the gold, while silver preserves its softness and gives it a greenish-white tinge. The general rule is, for base plates, to make the alloy of equal parts silver and copper, or with a slight preponderance of copper. For clasps, wire, &c. a very decided preponderance of the copper is given, in order to produce the necessary elasticity; sometimes a few grains of platinum are added for clasp gold. For solder rather more silver is given to the alloy than copper, and sometimes a few grains of zinc.* It must be remembered when coin gold is used to reduce from that the sovereign is already alloyed with $\frac{1}{12}$th copper, so that the alloy to be added must consist mostly of silver, in order that anything like equal quantities of silver and copper may be mixed with the gold. Thus in the four sovereigns there is 1 dwt. 17 grs. of refined copper; therefore the 4 dwts. 12 grs. of alloy to be added to

* This last addition is condemned by many dentists; while others recommend it, but only in *very small* proportion.

four sovereigns to reduce to 18-carat must be composed of 3 dwts. 2½ grs. silver, and 1 dwt. 9½ grs. copper, in order that the total alloy in the resulting gold shall be equal parts silver and copper.

Formulæ, recipes, &c., regarding gold plate, clasps, wire, and solders will be found at pp. 217—221.

Melting.—On this subject Mr. Gee says in his "Practical Gold Worker": "In preparing the mixture of gold, silver, and copper for the crucible, care should be taken in weighing them accurately, in order to prevent improvement or deterioration in the qualities of gold constantly in use. In melting all qualities it is a wise plan to place the lightest of the metals at the bottom of the crucible—viz. the copper first, the silver next, and the gold last; * by so doing, the melter is more likely to get a perfect amalgamation of the metals, as the gold, being the heaviest, is sure to find its way to the bottom of the pot. Plumbago crucibles are the best for all practical melting purposes, and, with care, will last from twenty to fifty times. If new, a very small quantity of charcoal powder should be put into the pot with the mixture of alloy. This coats the surface of it, and prevents the metals from adhering to it. When the gold is at the point of fusion, fling on to it about a table-spoonful of pure and perfectly fine vegetable charcoal. The layer of charcoal which forms upon the surface of the gold in the crucible protects the mixture from the action of the air, which would refine the gold by destroying

* In melting small quantities we have adopted the opposite order—melting first the gold and silver and then adding the more volatile metal, the copper.

some of the gold. When perfectly fused, the mixture must be well stirred with an iron stirrer (consisting of a long round piece of iron sharpened at the point), which should previously be made red-hot, to render the whole mass uniform in quality. The pot is then quickly withdrawn, and its contents poured into a suitable ingot-mould, previously warmed and greased to prevent adhesion. The warming of the mould is quite indispensable; but if made too hot, the metal, on being turned into it, will spit and fly about. Besides incurring great loss of gold, dangerous results may thereby happen to the person in charge. The same remark applies when the ingot is cold; therefore this part of the process must not be neglected, but carefully attended to. The ingot-mould, we may state, is hot enough when it will just stand touching with the hand for a second or so.

"When it is desired to produce very tough gold, use, as a flux, a table-spoonful of charcoal as before, and one of sal-ammoniac, adding it to the gold on the eve of melting. The sal-ammoniac burns away while toughening the gold, leaving the charcoal behind to perform the functions already indicated.

"For producing tough gold, the employment of common salt as a fluxing agent is sometimes strongly recommended. There is not, however, much to be said for its use, as it produces a very liquid flux, and is not half so clean as the one we have recommended. In the casting, unless very great care is exercised, it runs into the ingot-mould with the gold, producing a brittle-like substance;

and this forces itself into the bar of gold, the surface of which becomes irregular and full of holes. On this account alone, in preparing clean and smooth bars of gold it is objectionable. The same may be said of borax, but that is still largely used in the jewellery trade for melting purposes. Nevertheless, we are confident, from long practical experience (the result of many years' study and practice, during which time we have worked up many thousand ounces of gold), that there is no better flux than the mixture of *sal-ammoniac* and charcoal for *every* possible purpose required in the subsequent treatment of the different qualities of gold; and that for toughness, cleanliness, and producing good workable properties, it cannot be surpassed."

Scraps, or Cuttings and Filings.—These, if kept clean, and apart from the miscellaneous scraps and filings derived from repairs, &c., may, without difficulty, be melted by the process already described. In order to preserve them in this condition, separate trays should be provided for new work and repairs; and that used for new work should be cleared *frequently*, the gold being collected in a box until required for melting. That used for repairs, &c. will contain, even when the utmost care has been taken to exclude them, various substances which will render the rolling and working of the gold with which they are associated sometimes a very difficult if not altogether impossible process. These substances include small pieces of lead, iron, mineral, zinc, and platinum, &c. Iron is to a great extent removed by means of the magnet,

which should be repeatedly drawn through the scrap. Even should *slight* traces of this metal remain, it does not seriously interfere with the working qualities of the gold. It is different, however, with other metals. Tin, lead, antimony, or bismuth, if only forming $\frac{1}{2000}$th part, destroys the ductility of the gold. Exposure to the fumes of red-hot tin or lead renders it hard and brittle. Gold should therefore not be melted in a furnace which has recently been used for these metals. The plan recommended, as the best to adopt in these circumstances,* is to roast the scraps with nitre for half or three-quarters of an hour, adding small portions at a time. The melted metal may then be poured into an ingot-mould. The nitre removes the traces of zinc or iron which may be in the metal. If, after hammering, annealing, and rolling, it should still be found brittle, it must be remelted, and chloride of mercury used as the refining agent. This will remove the traces of lead or tin. Gee recommends that the scrap should be first melted as described for new gold; if the metal should then split in the rolling, remelt it with 2 parts carbonate of potash and 1 part nitrate of potash. Should it still prove brittle, melt again with a flux composed of 2 parts charcoal and 1 part corrosive sublimate (bi-chloride of mercury). When the scrap is very coarse, however, being made up of solder, platinum pins, &c., besides the baser metals referred to, Mr. Richardson advises the dentist to have recourse at once to the "humid" process of refining (that just explained being the

* Richardson's "Treat. on Mech Dent."

"dry" process). That is to dissolve the metals by means of acids, and then precipitate the *gold* from the liquid. This plan is not to be recommended for this reason, that, apart from the great amount of time and inconvenience connected with it, the cost of chemicals and the loss of gold is out of all proportion to the small amount of metal the dentist requires to refine; so that with the utmost care the money loss resulting very closely approaches what a respectable refiner would charge for doing the work.

When the scrap is in the condition described, the best plan is to melt it with an ordinary flux, afterwards break the crucible, and send the metal to a respectable refiner, who will, as the dentist desires, return the purified gold or its value in money, deducting a small charge for assaying and refining. Should, however, the dentist wish to make a trial of the scrap and filings himself, the following particulars regarding the treatment of lemel will assist him.

Lemel.—This consists of the gold dust and very small scraps, with which organic matter and other impurities are always associated. "Sift the lemel through a fine sieve, to separate the small portions of gold from the dust, letting the lemel fall on a clean sheet of paper provided for the purpose. This should then be carefully put into an iron ladle, and heated until all the organic matter is entirely destroyed. When the burnt lemel has sufficiently cooled, put the magnet through it, in order to collect and remove whatever iron or steel filings may be contained therein. The scrap should

always be separated from the lemel (gold dust). Then take—

Lemel or gold-dust	12 ozs.
Carbonate of potassa	2 ,,
Common salt	1 oz.
	15 ozs.

Well mix the lemel with the salts, and then place the preparation in a skittle-pot; after which place a layer of common salt on it, and transfer it to the furnace. A greater portion of the mixture should not be put into the crucible than will fill it to within one inch of the top, to be safe, as it rises in the furnace and may overflow. When the fire is at its height, the heat must be continued for half an hour longer. The pot, at the expiration of that time, must be carefully withdrawn, and placed aside to cool, when it may be broken at the bottom with a hammer, and the gold will then be found in a button. A little nitrate of potassa (saltpetre) may be added occasionally when it is in a state of fusion; but the saltpetre must be added with very great care, for if too much be put in, and organic matter be still present, it will rise above the top of the melting-pot and carry some portion of the precious metal with it. This may be prevented, however, by the timely application of a little dry common salt in powder."

The gold produced in this manner will be more or less below the quality usually worked for plate, and the dentist therefore may have to add fine gold in order to raise it to the usual standard.

"The pouring of the gold into the ingot-moulds

is an art which requires some little skill and practice. The flux floating upon the surface of the gold in the crucible may be prevented from passing into the ingot-mould by using a thin piece of flat wood held in the left hand: poplar wood is the

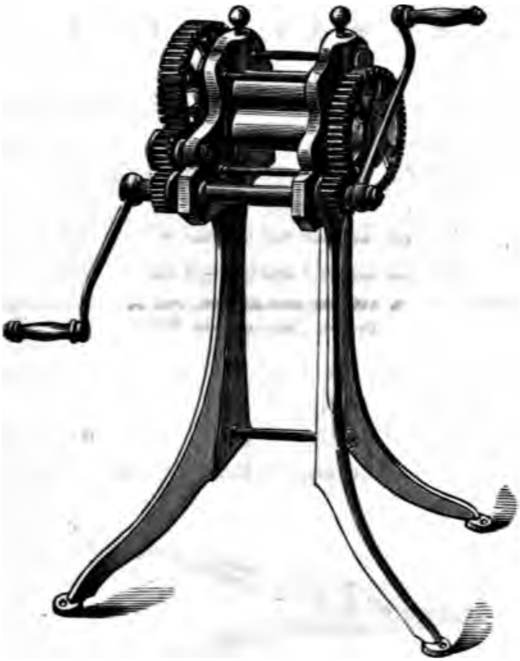


Fig. 25. Rollers for Gold.

best because it burns very slowly."* The gold is then filed along its edges, and may be reduced somewhat in thickness at the anvil before taking to the "rollers" (Fig. 25). The metal should be

* Gee's "Practical Gold Worker."

introduced between the rollers, in the course of the rolling operation, in the same direction; unless when it is necessary to "cross" so as to accom-

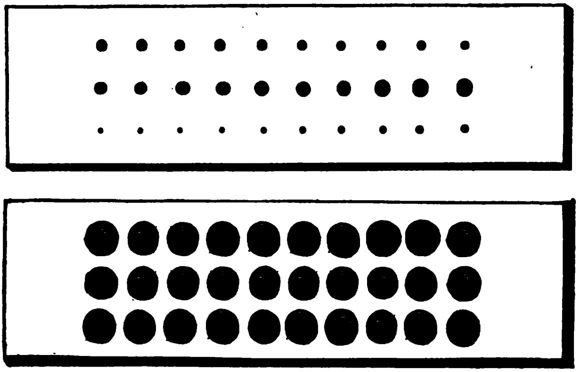


Fig. 26. Draw-plate for Wire.

modate the pattern lead, in which case the gold must first be annealed.

Clasp and wire gold is made of a mixture of gold, silver, copper, and sometimes platinum, or, without

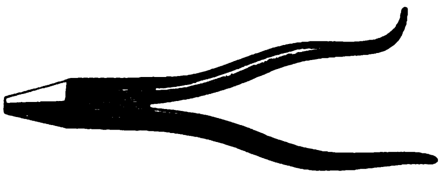


Fig. 27. Drawing Tongs.

the platinum, more copper is used in the alloy than silver. The various receipts for this kind of gold are given at page 219.

To make *wire* the bar of gold is only slightly

reduced in the rollers, and from this thick plate strips are cut by means of strong shears fixed in the vice, the gold being held firmly in the grasp of strong pliers. *Before* and *after* cutting, the metal must be annealed. The strips are then—their edges having been slightly filed—hammered on a small bench anvil so as to give a certain amount of roundness to the strips, which is necessary before submitting them to the draw-plate (Fig. 26). They are then annealed, and one end must be filed to a suitable point, which, being introduced in the hole of the plate, comes through and affords a hold for the pliers or drawing tongs, by which the rest of the strip is drawn through. The draw-plates may be fixed in the vice where there is no draw-bench, and the point of the wire being grasped firmly in the drawing tongs (Fig. 27) a sudden pull or fall back of the body will draw it through. The wire should be kept oiled, and be occasionally annealed.

CHAPTER IV.

THE BLOWPIPE.—SOLDERING.

The Blowpipe.—The dentist may employ the simple mouth blowpipe for his soldering operations, or he may use one which receives its supply of air from a bellows, or a third, the hydrostatic blow-

Fig. 28. Bellows for Blowpipe.

pipe, in which the inflow of water is made to expel the air contained in a tank or reservoir with such force as will give the blast required.

An ordinary bellows fixed to the floor, with an

elastic tube joining the nozzle of the bellows to the ordinary mouth blowpipe, with such slight modification as may be required for regular action by the foot, will serve as a bellows-blowpipe. More complicated machines may be purchased, however, and which, no doubt, act more satisfactorily, in which reservoirs are provided to equalise and maintain the stream of air.

A very simple form of hydrostatic machine is obtained in the following manner. One tank having been filled with water, another, made rather smaller, so as to fit easily into the first, is turned mouth downwards upon the water contained in tank No. 1. Thus the second tank is filled with air, which cannot escape except when a stopcock fixed in the top is opened. To this stopcock is fastened an elastic tube, the other end of which is attached to the blowpipe. To give force to the blast it is only necessary to add weights to the top of the tank containing the air.

Richardson thinks highly of the one represented by Fig. 29. It "consists of a tank or cylinder made of sheet iron, zinc, or copper, of variable dimensions, usually, however, from 4 to 6 feet in length and from 12 to 20 inches in diameter. To the side of the cylinder, near the bottom, a pipe with faucet is attached called the supply-pipe, and is designed to convey water to the tank, another is attached to the bottom, termed the waste-pipe, and is used to discharge the contained water. To the centre of the top of the cylinder is adjusted a stopcock to freely admit the ingress of air when the water is being discharged, without which the

sides of the cylinder would tend to collapse on the formation of a vacuum within. An india-rubber tube is also united to the top of the cylinder on one side, and is attached at its other end to an ordinary blowpipe or gas jet."

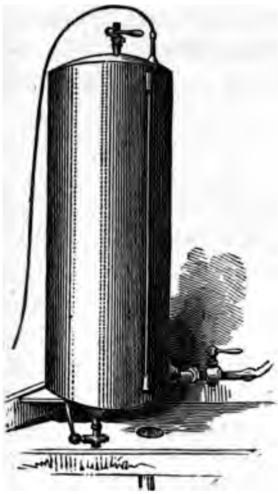


Fig. 29. Hydrostatic Machine for Blowpipe (Richardson's).

The simple mouth blowpipe (Fig. 30), however, is the one generally employed by dentists, and no other is really required in order to accomplish the *usual* soldering operations required for dental work. The flame by it can be regulated perhaps more readily and accurately than by any other means; and if the dentist does but take the little trouble required to learn the art of "keeping up the blast," even the longest soldering operations may be completed with perfect ease, and without that strain upon the chest which

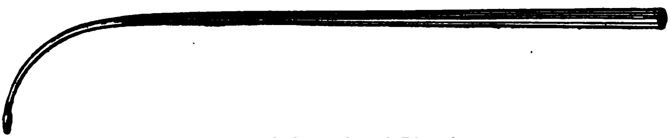


Fig. 30. Ordinary Mouth Blowpipe.

otherwise attends this work, and which has been the reason for most if not all having recourse to the machines referred to. The ability to maintain a

continuous blast is not difficult to acquire, as is often supposed; some come to it at the first or second trial, and *all* will overcome the difficulty after a few well-directed efforts.

"The art once learned," says Harris, "is never forgotten. But many will not master the first difficulty, and become the slaves to mechanical appliances which, however useful for many purposes, can never supply the place of the simplest and best of all blowpipes."

The following directions, given by an anonymous writer and quoted by Richardson, will point to the conditions required for maintaining the blast.

"The tongue must be applied to the roof of the mouth, so as to interrupt the communication between the passage of the nostrils and the mouth. The operator now fills his mouth with air, which is to be passed through the pipe by compressing the muscles of the cheek while he breathes through the nostrils, and uses the palate as a valve. When the mouth becomes nearly empty, it is replenished by the lungs in an instant, while the tongue is momentarily withdrawn from the roof of the mouth. The stream of air may be continued for a long time without the least fatigue or injury to the lungs. The easier way for the student to accustom himself to the use of the blowpipe is first to fill the mouth with air, and while the lips are kept firmly closed to breathe freely through the nostrils. Having effected this much, he may introduce the mouth-piece of the blowpipe between his lips. By inflating the cheeks and breathing through the

nostrils, he will soon learn to use the instrument without the least fatigue. The air is forced through the tube against the flame by the action of the muscles of the cheek, while he continues to breathe without interruption through the nostrils."

The bore of the point of the blowpipe should be of such a size as to admit a small knitting needle; and a disk or washer of bone or other substance may be fitted to the mouth end, so that the lips may rest *against* rather than close *over* the tube. The fatigue which overcomes the muscles, from keeping the lips closed over the tube, is the only inconvenience ever experienced when working for a length of time with the blowpipe, and this may in some measure be moderated in the way suggested.

Again, after soldering for some time moisture may collect in the tube and cause some annoyance when it is forced out at the nozzle along with the air. To prevent the escape of the moisture in this manner, a bulb or small globe of brass may be fixed in the pipe, about the middle of its smaller half. The moisture then travelling along the inside of the tube falls into this bulb, and is retained until the soldering is completed. Some of the blowpipes sold with the bulbs are not really made upon this principle, but the latter are merely soldered upon the plain blowpipe and have no communication with the interior of the tube. We have found this several times to be the case with blowpipes purchased from dealers in *watchmakers' materials*.

Soldering.—To solder successfully, the following points must be observed: 1st, the joints must be closely fitting; 2ndly, they must also be perfectly

clean; 3rdly, the flame requires to be directed and managed skilfully; 4thly, the solder should be well suited to the work it is used upon, and flow smoothly.

It is most essential to have the joints fitting close. Without this condition satisfactory results are impossible, and to obtain it care and skill must be employed. The second requirement is next in importance: the joints should be *clean*. To effect this, the parts to be soldered must first be scraped, to remove the oxidised surface of the gold, and then be covered with a solution of borax, in order that the surface may be *preserved* in a fit state for soldering. The borax solution is made by rubbing a lump of borax upon a slab of slate, or of rough ground glass, with water. In the solution thus made the pieces of solder are placed, and the joints are touched with the solution either by using a hair-pencil or a small piece of wood cut to a chisel edge—this last is most convenient in many cases. In soldering gold the borax solution must be very sparingly used; when it is used in excess and in a careless manner, it acts as a most effectual *barrier* to the running of the solder over the parts where it is desired. In soldering silver a liberal application of borax is necessary, and, after the case has been heated up to soldering point, the solder should be touched with a borax lump. Also in heating up the case after borax has been applied, the heat should be imparted *gradually* at first, otherwise the borax will swell and displace the solder. The third requirement is a careful management of the flame. Various *forms* and

shades of flame are obtained by means of the blowpipe. The former depend upon the position of the point in relation to the jet; the latter upon the force of the blast which is sent through the tube. With the point of the blowpipe held at a little distance from the jet a broad flame is obtained. If the blast be a strong one, the colour will be blue; if weak, white. With the point held just within the jet a pointed flame is obtained, the colour, as before, depending upon the force of the blast. Between these extremes we have others, in which the white and blue and broad and pointed are associated in various proportions. Of all these the most suitable for our purposes are the broad blue-white flame (mostly white) for heating up, and the pointed white flame for reducing the solder. The entirely blue flame should never be employed. As to the management of these flames, the rule should be to heat up the *plate* with the flame described, as if it were our design that the heat of the *plate* should melt the solder; when the solder from this action *begins* to give way, then the pointed white flame may be turned sharply upon it. The fourth point—that the solder should flow smoothly and freely—requires that the gold used for the soldering shall be of an inferior quality to, and therefore more fusible than, the plate to be soldered. At the same time it must be remembered that it is most desirable that there should be as little difference between the two golds as possible. Thus for 18-carat plate Richardson advises a solder 16-carat fine; then, supposing that the solder we use is as indicated about 2 or 3 carats

below the plate it is used upon, and that it has been well-mixed and melted, the smooth and satisfactory flowing of the solder altogether depends upon careful attention to the three *first* conditions to which we have referred.

CHAPTER V.

THE SWAGING OR "STRIKING UP" OF PLATES.— CLASPS.

THIS is, according to the model, a very simple operation, or the opposite. Most edentulous cases, and partial ones with shallow teeth standing, are very easily swaged between the zinc and lead models so as to fit the plaster cast; but lower partial models with long teeth standing over which the plate must be struck will be found sufficiently difficult.

Suppose the case in hand is an edentulous upper, belonging to the first class, and for which a gold plate is required. It is first of all necessary to have a line drawn upon the plaster model which will indicate how far the plate is intended to extend in all directions; sheet or pattern lead is then pressed over the model, and cut so as perfectly to represent the future plate, the traced line being the guide. The pattern is now taken from the plaster model, flattened carefully, and placed upon the gold plate, which may at once be cut by the bench shears according to the pattern, or a point may be used to trace the latter more exactly upon

the gold before cutting. Some advise that the gold should be left slightly larger than the pattern to allow for trimming and *slipping*. We think this is a mistake: the slight extension of the plate which results from the striking is amply sufficient to allow for trimming; and as regards the slipping, this is an evil which must be guarded against in a very different manner. The ragged edges which have been left by the shears are filed away, and the plate annealed by means of the blowpipe flame. When gold is heated to redness for this purpose, it may be cooled at once in water, since no rehardening takes place, as with steel, &c.

The first part of the swaging is now proceeded with; and it consists of beating the plate into shape upon the zinc, by means of horn, bone, or wooden hammers.* The plate is held by the fingers of the left hand in position upon the die, whilst the pointed end of the hammer is used upon that part of the plate covering the palate. Having got the palate to fit in a suitable manner, we next proceed to the alveolar ridge and the outer edges of the plate.

This part of the operation must be done very gradually and carefully in some edentulous cases which exhibit a tendency to "fold." This folding of the plate, which generally occurs in front, in a line with the frœnum, may be prevented by frequent annealing and persistent use of the mallet. In an exceptional case, however, it may be advisable to cut a narrow wedge-shaped piece out of the

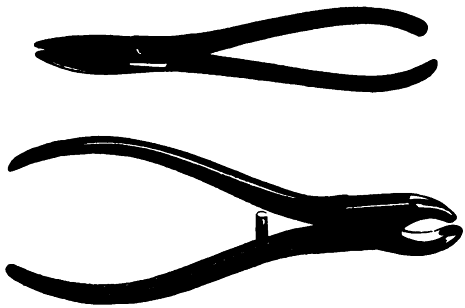
* Horn hammers of most convenient shape for this purpose may be had at the depôts.

front part of the plate; the edges close over each other as the striking proceeds. When the plate is fitted, these edges are dressed and soldered with the hardest solder (Ash's No. 1, for example).

During this and the subsequent fitting of the plate, particles of the zinc and lead adhere to the surface of the gold, which is in danger of being injured by their contact when it is heated, or annealed upon the charcoal. To prevent these metals from contaminating the gold, a layer of paper is sometimes placed between the zinc and gold, and between the latter and the lead when swaging. Oiling of the plate is also said to prevent the adhesion of the base metals; but we prefer to use the pickle acid for this purpose. This should be kept warm, and in some convenient place where the fumes may escape harmlessly. Before annealing, the plate is immersed in the warm acid, which at once clears it from the adhering metals. By this plan no time is wasted and all danger is avoided.

The plate having been sufficiently fitted by means of the mallets—during which process it should be more or less frequently annealed according to the peculiarities of the case—it is now placed between the die and counter upon the striking block or anvil. A sharp blow is then given upon the zinc with the swaging hammer, after which the plate is examined to see whether it is being struck into proper position; assured of this, it is replaced between counter and die and the striking proceeded with. When the plate has been struck into the shape of the first zinc, it is placed upon the plaster model—which in some simple

cases it may fit perfectly at this stage—and reduced to the proper dimensions. If there is much surplus, the best way to do this is to go round the plate with a marking point, tracing its outline upon the plaster model. Now take off the plate, and as there are two lines on the model—the outline of the plate as it should be, and the one just drawn, the outline as it *is*—the eye is at once afforded a reliable guide for this operation, which is performed by means of the shears (Fig. 31), punching pliers (Fig. 32), or



Figs. 31 and 32. Shears and Punching Pliers for Plate.

file. The plate, as has been said, may fit the plaster impression correctly at this stage; but the fitting is generally defective, and the striking must therefore be continued upon a second or even third die and counter. The usual practice is: for a model which presents no special difficulty, two dies and counters are provided; for the more difficult models, three dies and counters are made. Trouble is sometimes experienced from the splitting of the zinc die while swaging. If a thick washer or iron punch is interposed between the striking hammer and zinc, this

annoying accident is not likely to happen. The punch should be of such a height and shape that the left hand may grasp it while striking with the right.

It is by no means certain, however, that a correct fit will be obtained by using even the larger number of dies. For example, a suction upper plate, coming from the last and best die, does not accurately fit the plaster impression, but rests or grasps along its outer edges on both sides of the model, leaving the plate open along the line of the palate. This is owing to the contraction of the zinc: in reality, the plate has been struck to a model slightly smaller than the plaster one, so that when it is placed upon the latter it must ride or grasp upon the outer edges. To correct this defect the "fusible metal" models have been tried and recommended by some dentists; but these, as has been observed, have defects of their own which render their use objectionable. A more usual method for correcting the fault of the zinc die is to place one or more layers of damped paper along the outer surfaces of the zinc along which the plate grasps; the latter is then closed over these upon the die, and then struck between the die and the counter. But the most effectual and satisfactory method, according to our experience, is to take that part of the plate which grasps, between the fingers, and bend it out with a sharp decided motion of the thumb. The best way to hold the plate, so as to get the proper purchase and so as to see exactly what you are doing, must be ascertained before attempting to bend it. If it grasps upon a particular part or

point, rather than along a considerable length of its outer borders, we use pliers, and give the plate a sharp *pull* rather than a bend at the point where it rocks. An ordinary pair of pliers, in which the square jaws have been *rounded* away in such a manner as not to *mark* the plate, are most convenient. By one or other of these plans a misfit, which can be certainly attributed to the shrinkage of the zinc, may be rectified.

Suction Chambers.—A chamber may be made in a plate by swaging or by soldering. For the first it is necessary to fix on the palate of the plaster model, previous to sand moulding, a piece of wax or metal, which must exactly represent the height and extent of the desired chamber. This is, of course, reproduced in the zinc, and a corresponding chamber is made in the plate in the usual course of the swaging process. A sharper outline is given to the struck chamber by going round its edges with the steel or copper punch.

In order to solder a chamber an outline of the shape desired is drawn upon the plate. A hole is then pierced to allow an entrance for the small frame saw, which is made to cut out the part indicated. A piece of plate, of the form desired for the chamber, is next fitted, so as to cover the opening in the main plate, and to make a perfectly close joint with it. When this has been accomplished, the edges must be prepared in the usual way for soldering, and the chamber is then fastened in position by means of wire clamps (Fig. 33). These last are made of steel or iron wire—thickness of pin-wire generally—and are of different sizes.

Take a piece of wire about two inches long, bend it over the round pliers so that the ends shall meet upon each other, and a medium-sized clamp is formed. The case is then placed upon the charcoal and soldered. This will be very easily accomplished if the joint in the first instance has been made a perfectly close one. Small pieces of solder should be used.

Partial Plates.—These, if the teeth standing on the model be short, are very easily struck into shape; the pattern lead should be cut to the *exact*

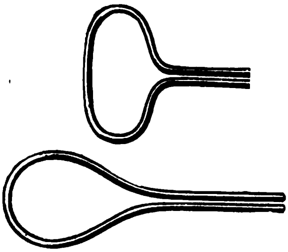


Fig. 33. Wire Clamps.

Fig. 34. Zinc Cast with Teeth reduced to facilitate swaging.

size upon the plaster model, and the plate, if it has also been cut exactly to pattern, may be struck between the first zinc and lead, without filing down the teeth of the former, as it is necessary to do in the cases presently to be referred to. Many plates are rendered unnecessarily difficult to strike by leaving the pattern lead over those teeth—bicuspids and molars—which are subsequently to be clasped. In all such cases the pattern should be cut so as to fit accurately round the necks *only* of these teeth. Those models on which bicuspids

and molars of considerable length are standing, to the top of which the gold plate must be struck, are sometimes difficult to strike to; and it is in these that we find the tendency to "slip" during the swaging process. It is found advisable in such cases to reduce the teeth of the first zinc to within about an eighth of an inch of the gum (Fig. 34). Otherwise, with long teeth standing the mallet could only be made to fit the plate to the model in a very imperfect manner, and if the former were struck in such a condition between the die and counter it would split in all directions; but with the teeth shortened to the extent mentioned, the plate can be very readily struck into shape. Instead of filing them down upon the zinc model—a somewhat laborious exercise in certain cases—the impressions of the teeth in the sand may be *filled* to the extent required. The surfaces in either case must be solid, smooth and rounded at the edges. The pattern for the plate may be cut upon the plaster cast as usual; but it will often be found most convenient to fit it to the reduced zinc cast, leaving it "full" over the surfaces of the filed teeth, so as to allow sufficient material for striking to the height required. The plate cut from the pattern is then fitted in the usual manner with the mallet and afterwards at the block upon the first or filed zinc. It is then placed upon the second zinc, and forced into shape by the mallet and bone punches; more or less frequent annealing being necessary to prevent splitting. It may now be struck at the block; but here it is necessary to observe certain precautions which shall prevent its slipping. This is a

difficulty frequently met with in lower partial plates or bridges. In such cases it is designed to fit to the top of the long teeth behind which it passes; but, after striking between the second die and counter, the plate is found to have slipped down from the position upon these teeth which it should occupy.

This is the result of the manner in which it was placed between die and counter; for if the plate and die be struck into the resisting lead, both are not sent *home* together, but the plate is held back by the lead while the zinc passes by itself down to its proper seat. If the simple precaution be taken of placing the plate in the *lead* before striking, instead of upon the zinc, "slipping" will never be encountered. But it is not sufficient to place it loosely in the lead and then close the zinc upon it and strike. Care must be taken that it is placed sufficiently *deep* in the lead counter before striking. To accomplish this in some instances it will be necessary to use the horn hammer, and even the round-edged pliers; the more difficulty there is experienced in doing this, the more reason is there for taking the trouble. Through the whole process of "striking" the same manner of placing must be observed, for the friction between the plate and lead, when the former is driven down with the die, has a constant tendency—even when the counter has been widened by repeated striking—to draw it down from the teeth.

If it is intended to have the plate "punched" round the standing teeth, that should be done upon the second zinc. The copper or small bone punch may be first used. It will fit the plate sharply to

the necks of the teeth, and so indicate the line to be followed by the steel punch. The latter (Fig. 35) must then be used with great steadiness, keeping it in constant and regular motion along the line required. The plate then, if accurately fitting the plaster model, is prepared for the "clasps."

Fig. 35. Steel Punch for chasing.

Clasps.—Partial cases are generally supported in the mouth by means of clasps. These may be formed from gold plate, or from gold wire.

The "plate clasps" are the most satisfactory which can be employed for the great majority of cases. The objections to the use of the "wire clasps" are that they are ineffective as a fastening, and destructive in their action upon the natural teeth round which they are placed. They are ineffective because, first, they are too narrow to give a steady support to the case; and, second, they act upon that part of a tooth which is not well adapted for the purpose of holding—viz. the neck. Then the wires are destructive, because, being narrow, and acting along the line of the tooth least protected by enamel, they act rapidly as an abrading power, cutting into the substance of the tooth sometimes to a considerable depth.

The effective support obtained by plate clasps may be best observed and contrasted with those made of wire in the case of a narrow-necked bicuspid or canine tooth.

Suppose a wire clasp is fitted for the tooth figured; when the case is finished and about to be placed in the mouth the dentist bends the wire to the small circumference at *b*, and the theory is that the wire will stretch sufficiently to pass over the thick part of the tooth at *a*, and reclose and grasp again the small neck when it passes to *b*.

Fig. 36. Bicuspid Tooth showing the ineffective action of a wire clasp.

In practice this does not happen; if the wire has lost its elasticity in soldering the flat teeth, it closes but little, if any, after passing *a*, and a wire retaining the best possible spring is still unable to close upon the narrow neck of a large-crowned tooth. The second figure shows a plate clasp fitted to the same tooth; as the denture to which it is attached is pressed "home," the clasp continues to act upon *a*—the broadest part of the tooth—which it does not pass, and therefore continues to grasp in a perfectly satisfactory manner.


Fig. 37. Bicuspid Tooth fitted with plate clasp.

The points which must be observed in order to obtain the best results from this method of clasping are elasticity, shape, and disposition. First, the clasp should grasp the tooth by its elasticity, and as this quality depends—other things being equal—upon the thickness of the plate used, the latter must be as thin as the other circumstances of the case will allow. Those other circumstances upon which this thickness of the plate must depend are the breadth and the length of the proposed clasp. For example, a very long bicuspid or molar must be fitted with one made of

thinner plate than would be used for a much shorter tooth, and by thus varying the thickness we obtain an equal spring or elasticity for the two clasps.

Again, the length of the spring must also be considered; for instance, a clasp made to surround a molar of large diameter will require to be thicker than would be the case if a short one acting only upon the *side* of the molar was employed. In connection with the elasticity of plate clasps it must be remembered that this also depends upon the way in which they are soldered, and, though otherwise perfect, the satisfactory action of a clasp may be rendered impossible by the careless performance of this operation. A short one, for example, acting only upon the *side* of a bicuspid, must be soldered *only* at the back part of the clasp, thus leaving the whole side perfectly free as a spring. A long clasp extending round the face of a molar, on the other hand, should be soldered right round the back and side as well, thus leaving only that part free which covers the face of the tooth.

But besides varying the thickness of the plate and the disposal of the solder, according to the peculiarities of the clasps, in order to have them uniformly elastic, we must vary the thickness also, in order to accommodate the *condition* of the teeth as found in different mouths. For instance, in the case of particularly large and firmly fixed teeth, we must use somewhat thicker plate than usual, whereas in the case of teeth which are slightly loose, plate must be used which is particularly thin; and if this precaution be taken, observing also what has

been said in regard to soldering, these clasps will act in a most satisfactory manner in the latter case. The shape of a clasp must of course correspond to the shape of the tooth round which it is to act; a canine tooth requires, for example, that its clasp should be low at the back, and rise to a high peak on each side; while upon molars and bicuspids the clasps may be kept at an almost perfectly regular height all round. This kind of fastening, it may generally be said, should rise as high at all points as the thickest and most prominent parts of the wall of the tooth which it surrounds and acts upon. Canine teeth are well adapted for clasping if the "bat's-wing," or side clasp, be used.

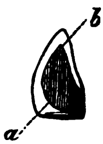


Fig. 38. Canine Tooth fitted with plate clasp.

The accompanying figure shows one side of a canine tooth fitted with this description of clasp; it is rounded off at *a*—the neck of the tooth, which gives no holding surface—but it is carried full up to *b*, which is the widest part of the canine, and which gives a most effective hold.


Fig. 39. Bicuspid Tooth fitted with plate clasp.

A bicuspid clasp, acting along both *sides* of the tooth, acts most satisfactorily.

The usual shape of such a fastening as it fits against the side of the bicuspid is shown in the figure.

The advantages of these side clasps are that they act most efficiently, and they do not "show;" indeed, it may be said that their efficiency depends upon their not showing, for if they were carried

round upon the face of the tooth they would not act so well. Lying, as they do, against the sides of the natural teeth, the artificial ones may be fitted over the front border of the clasp so as to perfectly conceal it.

For the molar teeth no very uniform rule can be given. In the case of canines and bicuspids the sides are almost invariably the only holding surfaces, but the molars afford a good holding surface in all directions; and the fitting of a clasp round the face of teeth placed so far back in the mouth is not so objectionable on the score of appearance as with the others. The molar clasp, therefore, is sometimes made entirely to surround the tooth, sometimes it acts only at the side, and oftenest, perhaps, it occupies a middle position between these two. Their length depends upon the conditions of each case; as regards their shape or breadth, the same rule applies as for the bicuspids. In the case of a molar such as that sketched in Fig. 40 the clasp may rise high up on the side of the tooth as at *c c*; but round the face at *a*, and the back at *b*, it will be observed from the shape that the clasp should not rise higher than the points indicated.

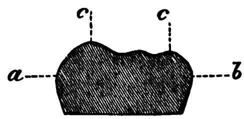


Fig. 40. Molar Tooth showing the height to which the Clasp may be made.

Arrangement or Disposition of Clasps.—This is a very important point, for without a correct adjustment or arrangement, so that they will act against each other and against themselves, the most perfectly shaped clasps will be useless.

Having decided in any given case as to which teeth are most suitable for clasping, it must next be considered how a proposed clasp will act when tightened; that is, in which direction will it tend to draw the plate? When this has been ascertained, another must then be provided which directly opposes this tendency by pulling in an opposite direction; then, so far as these two are concerned, the arrangement is perfect. A double bicuspid clasp, which closes upon both *sides* of the tooth, is a perfect arrangement. Here, if the clasp be tightened on one side of the tooth, its tendency is directly resisted by the opposite one, and the plate remains fixed in its true position. Again, if a clasp be carried round from the back part of a molar, covering the posterior half of its wall, and another round the front of a bicuspid on the same side of the mouth, these together would form a perfect arrangement. But suppose the same back-acting molar clasp was used with one similarly fitted round the *back* of the bicuspid instead of round the front, such an arrangement would result in failure, for both clasps would draw in the same direction and unsettle instead of fasten the plate.

We are not, however, always able to resist the action of one clasp by that of another in the way described. How shall a plate carrying bicuspids and molars be fastened, where only the front six natural teeth are standing, with no space between laterals and canines? This is one of those exceptional cases where the "side clips" are useless; for there is no clasp or point to resist their action, and a plate fitted with them would simply be un-

settled, and would fall back into the mouth in the direction of the arrow, Fig. 41, if they were closed. The clasps in such a case must be fitted completely round the *face* of the canines in the shape of a narrow band near the gum, as traced by the dotted line *a b*; and they must be soldered round the back and *side* of the tooth, so that the only acting part shall be the narrow band in front. Then the latter when tightened will be resisted by the gold at the back.

Again, where only one or two natural molars remain on each side of the mouth, a clasp fitted round the front of the molars *only* will incline to unsettle the case and force it out of the mouth. In these cases, supposing the second and third molars to stand together on both sides of the mouth, then a clasp should be carried round the back of the third molar to resist the tendency of the one fitted round the front of the second. Fig. 42 shows a case of this kind. Here if clasps were fitted only round the front of the molar and bicuspid at *a*, the case would not *sit* satisfactorily, therefore we carry clasps round behind the molar to *b*. As the third molar is generally very short a wire clasp may be used. Where this back clasp *cannot* be applied, then the one round the front of the second molar should encircle that tooth back and front as far as possible, and it should be soldered (as in the last

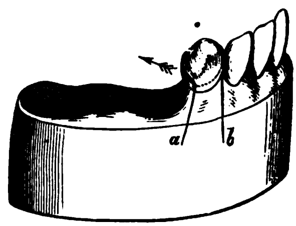


Fig. 41. Model, with Plate, showing the action of Clasps.

case) round both back and side, so that the band covering the face shall act against that at the back of the tooth.

Wherever it happens that a finished plate, ascertained to be itself a good fit, begins to spring out of position when the clasps are tightened, it may be concluded that either the latter have been badly arranged or that they have been tightened in an injudicious manner. In the latter case they should all of them be opened until the plate fits steadily

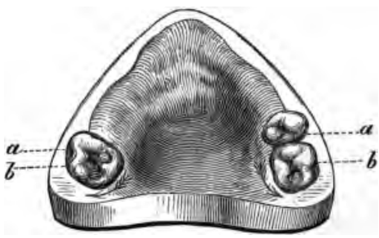


Fig. 42. Model showing how Clasps should be placed.

again, when the reclosing must be done with particular care.

Fitting the Clasps to the Teeth and Plate.—It is necessary first to take a pattern in lead-foil. The foil must be pressed accurately into the shape of the tooth, and then cut carefully to the exact size of the desired clasp. If the pattern has been accurately fitted to the tooth and the gold band cut exactly to the dimensions of the lead, little difficulty will be experienced usually in bending the gold into the shape of the tooth. In cases of special difficulty, it may be advisable when a fair fit has been obtained

with the pliers to place the clasp between the lead and zinc and strike it into shape. The impression of the tooth in the counter should be slightly enlarged with a graver, and the clasp inserted into it (the lead) instead of upon the zinc before striking, in the manner already described for preventing the slipping of plates.

When the clasp has been fitted and "dressed," the main plate is then filed just sufficient at the neck of the tooth to allow the clasp to pass down into position between the main plate and the natural tooth. In the case of long molar clasps, or others intended to act only upon the front of the tooth, the joint should be made close round the back and *sides ;* but for short side "clips" the joint should be close along the short line at the back, where *only* the solder is to run, and from this point forward along both sides the main plate may be made to taper away neatly from the clasp to a slight extent. This will give a more finished outline to the plate, and also leave free working room for the band. The joints should now be scraped, and the clasp united to the plate with wax cement; the latter will hold more securely if the parts be slightly heated before applying it. The plate with clasp attached is now carefully taken from the model, and its lower or palate surface imbedded in equal parts of plaster and sand, made into a paste with water.* When this has set, the wax is removed from the joints, which must then be thoroughly cleansed and prepared for soldering. The case is then heated, in order to dry the plaster.

* See p. 256.

This must be done slowly at first, or the parts will spring asunder. When dry, it is placed upon the charcoal and soldered, or a preliminary heating may be given in the fire or stove. The pieces of solder should be small for this work, and should be placed upon the joint and leaning against the clasp. There is no difficulty about the soldering if the joint is closely fitted and clean.

The plate is then disengaged from the investient, cleaned in the pickle-acid—if it is to be tried in the mouth at this stage—and after washing thoroughly, it is ready to receive the biting blocks.

Strengthened Plates.—Nearly all lower plates require to be strengthened by soldering a second plate to the first, and the same operation is sometimes necessary with upper plates also.

In such cases the first point to be decided is whether the second or strengthening plate should be soldered on the inside or on the outside of the first or main plate. This should entirely depend upon the relative sizes of the plates. A strengthener nearly as large as the main plate should be soldered on the outside or lingual surface of the other. A narrow strengthener, on the other hand, should be soldered on the inside or palate surface of the main plate; for if a large strengthener were soldered on the inner surface an unsteady fit would probably be the result—the plate would rock upon the strengthener. This result is of course most noticeable in an upper case. With narrow strengtheners there is not the same tendency, for in the striking they get readily sunk in the main plate, and for the sake of appearance these may be soldered on

the inside or palate surface. Before cutting the pattern in lead for the second or strengthening plate, the other should be tested and its weakest points ascertained, for over these the strengthener must be left broader than elsewhere. When a partial plate is strengthened it will often be advisable to carry a tongue of the strengthener into the spaces where one or two artificial teeth will stand isolated. This is more especially required in the case of tube teeth—in these the pin should be soldered through both plates; it is also necessary in cases where the teeth are long.

The plate from which the strengthener is made is usually thinner than the principal one; how much thinner depends of course upon the peculiarities of the case. Narrow lower plates require stronger strengtheners than upper ones do.

The strengthener, having been struck into position and fit between the metal models in the usual manner, is then placed in position upon the main plate, and both are struck together between the die and counter. They are then scraped over the surfaces to be united, and the borax solution sparingly applied; the two are now grasped at different points by the wire clamps, which hold them securely together during the soldering operation. It is best to only partially solder them in the first instance, or "tack," as it is called; that is, three or four small pieces of solder are melted at considerable intervals round the joint; the case is then examined, and if the edges are closely fitting, the soldering is at once completed. To do this satisfactorily, the solder should be used in narrow

pieces, and placed along that line of joint only which stands highest as the case lies upon the charcoal, as indicated by the arrows, Fig. 43. Now when the plates are heated and the solder flows down between them, and appears along the lower line of joint, we know that it must have traversed the entire surfaces of the plates to be joined, and may therefore consider the union to be complete. When the solder can be clearly traced in a continuous line round the plates, the sharp edges may be reduced with the file, and

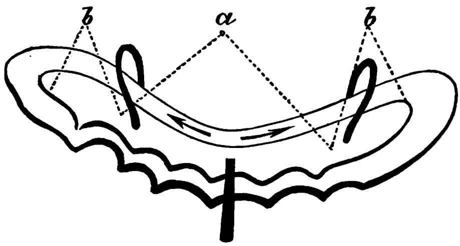


Fig. 43. Lower Plate and Strengthener, clamped and ready for soldering.

the clamps having been replaced, more solder may be added for the purpose, if necessary, of flushing the joints. The flame required for this work is the broad blue-white flame throughout.

If, however, after "tacking" the plates we find that the edges are not sufficiently close, they must be again struck at the anvil, where but little force is required to complete the fitting. The soldering is then proceeded with as described. From the point where the two plates are "tacked" until the operation is completed they should not be placed

in the cleaning acid, as it leaves a surface between the plates unfavourable for soldering; the base metals which may adhere after striking should therefore be removed with the scratch-brush. Striking the plate after the soldering has been completed has a tendency to "start" the solder; it should therefore be avoided if possible. In the after stages of working, if it be necessary to heat up the plate again as in soldering clasps, pins for tube teeth, &c., the *clamps should be replaced.* Some trouble may be experienced in these after heatings from the solder of the joined plates melting. This may be entirely prevented if a strong solution of borax be liberally applied round the whole joint, and vitrified by heating up the plates, using the blue flame to melt the borax. Of course strong wire clamps must grip the plates while this is being done. By this means a thin coating of glass is given to the whole surface of solder, which is thus thoroughly protected and preserved unaltered all through the construction of the plate. The strengthener should, as a rule, be soldered before attaching the "clasps;" and the solder used should be higher in quality than that used for subsequent operations. With 18-carat gold for the plates and 16-carat (Ash's band) for the clasps, we have always used No. 1 solder for the strengthener, and No. 2 for clasps, &c.

CHAPTER VI.

TAKING THE "BITE" IN WAX AND PLASTER.

In small partial cases it is usual simply to take an impression of the opposing teeth; and the operator, having observed the manner in which the patient naturally closes the mouth, is able, when the model of the opposite teeth is made in plaster, to join it with the other in the correct manner. In most of these cases there are sufficient indications on the cusps of the teeth to show how the models should be joined to represent the natural bite.

With large upper and lower cases, however, a different method is adopted. Wax is softened and formed into a block round the ridge of the plate. It must be of such a height and shape as will take the impression of the teeth of the opposite jaw when the mouth is closed in a natural manner. In the case of an edentulous upper, or of a complete set of upper and lower, we have no guide on the model, as with partial pieces, as to the height and fulness required for the biting blocks. In such cases the wax must be formed along the ridge of the plate, according to such indications of the required height as may in the first instance have

been obtained from the mouth itself. And it is well to leave the blocks somewhat in excess, both as to height and fulness, so that upon trying them in the mouth they can be cut down to what may be taken as the natural depth of the bite, and may also be reduced in front to that shape which gives the best expression to the face. Both these conditions will more readily be obtained by reducing than by building up the wax. If the precaution be taken of heating the plate just sufficient to melt the surface of the wax when *placing* the blocks, the latter will remain perfectly fastened during the subsequent stages.

Getting the patient to bite correctly is a well-known difficulty. Dentists of experience say that a wrong idea is conveyed to the mind of the patient when he is told to "bite;" this seems to suggest that a point to point closure of the teeth is desired. The expression "close the mouth," or "bring the side teeth together," may therefore induce a more natural articulation. Again, the patient may be asked to "swallow," and that movement almost *compels* a natural closure. Perhaps the most valuable suggestion, however, is that which points to the tactics of the painter who draws the attention of the sitter away from the object of his visit by conversing upon other subjects, in order to obtain the natural expression he desires. False bites are no doubt often the result of the patient's anxiety over an operation upon which so much seems to depend.

When the wax blocks for an upper and lower set have been reduced to the depth and fulness

most natural for the case in hand, and when the operator is satisfied that he has discovered the natural bite of the patient, the latter must be made to keep the mouth closed in that manner while a line is drawn down the face of the block to indicate the centre of the mouth, and others are cut across the joints at opposite points, to serve as guides for accurately rejoining the blocks in the work-room.

Casting the Bite.—The simplest method, and one very often employed, of casting bites is the following. The plates (supposing the case to be a complete set) are put on the plaster models, and the wax blocks—which should be perfectly dry—are joined exactly in the position indicated by the cross cuts; and the parts—models, plates, and blocks—may then be fixed with the wax cement. Plaster is now mixed and shaped on the bench to the form of a square slab, and the ends or backs of the models are imbedded in the thick plaster slab. The backs of both models should be oiled before imbedding them. When the plaster is hard the models may be withdrawn from the slab, and the setting of the teeth at once proceeded with. Or the bite may be cast in this way. The backs of both models are cut in rough dove-tail fashion, so as to give a good hold to added plaster. Then one of the models is placed flat on the bench, and plaster added to

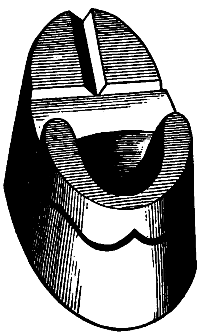


Fig. 44. Model with added Block for Bite.

this roughened surface, building it in the shape of a flat block to the back of the model. The surface of this plaster must receive one or more grooves (Fig. 44) or cuts, made so as to allow the parting of that which is to be filled into them. The blocks, plates, and models are united as before, and the grooves of the added block having been oiled, plaster is mixed rather thick, filled into the grooves, and built up (Fig. 45) to the roughened back of the other model. When plaster is to be united, as here,

Fig. 45. Model with Bite cast.

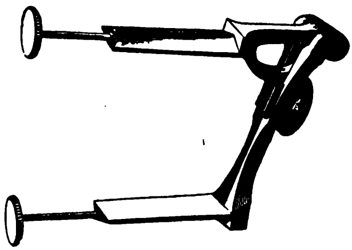


Fig. 46. Articulating Frame (Graham and Wood's).

to a roughened surface, that surface should be moistened in order to effect a secure union.

Another kind of working bite—the best of all—is obtained by using an articulating frame. The simplest form of this implement acts on a single joint (Fig. 46); and if this joint be well made, the simple articulator answers the purpose well. They are made of brass or gun-metal, and in a variety of shapes, as may be seen in the catalogues. The base or bottom of each model is roughened, and the parts (biting blocks and models) fastened in position with cement; plaster

is then mixed and added to the roughened surfaces of the models, and the arms or suspenders of the articulating frame—which have been previously oiled—are closed upon the added plaster, and imbedded and covered over by it (Fig. 47). Other forms of articulators are made with joints which permit movement in every direction. These are no doubt useful where a *false* bite has been obtained from the patient; for, a correct one having been afterwards obtained, it is not necessary to recast in plaster as with a simple articulator, but by simply accommodating the screws to the new "bite," the change required is at once accomplished, the screws being retightened to preserve the new articulation.

Fig. 47. Bite cast to Articulating Frame.

An articulator of this description has been introduced by Mr. Davidson, which seems perfect in every way; and it has this advantage, that the suspenders may be imbedded in the plaster while casting the impression as taken from the mouth; afterwards, when the bite is obtained, the joints are accommodated to it, and fixed in position by means of the screw. Many of the advantages obtained by working with an articulator are well explained by Mr. Davidson, but a very important one may be added, viz. that we are enabled by this means to see the inside range of the teeth, and we can thus readily provide a perfect articulation of

their grinding surfaces. By the other bites we cannot see the inside cusps, and we can only be assured that the articulation is good as regards them by a somewhat troublesome process, which is therefore often neglected.

Bites for partial cases may be cast by first cutting a perpendicular groove on the back of the model, then filling plaster into the impression of the teeth in the wax block, also into the groove on the model, and joining the plaster as you would build a bridge. The groove and all parts of the model likely to be touched by the plaster should of course be oiled.

In the case of edentulous or nearly edentulous uppers or lowers, it is of great advantage to take a *full* impression of the opposite jaw; when this is cast and separated, its teeth are closed into the impressions made in the biting block, and the bite cast as described for complete sets. The advantage of having this model of the opposite jaw is that you are at once provided with a guide as to the character and disposition of the teeth required for the case. In small partial pieces the adjoining teeth are sufficient guide; but in an edentulous upper, for example, the only guide we can have is a complete impression of the lower teeth. When this is before us we can tell by *their* length, projection, and form what is required for the upper set.

Where there are few opportunities of trying cases into the mouth, and where the dentist, having taken model and bite, leaves the construction of the set entirely to his assistant, the above system should be invariably practised.

CHAPTER VII.

SETTING OF MINERAL TEETH ON GOLD PLATES.—SWIVELS.

Flat Teeth.—Where the teeth of a set or a partial set are to be fitted entirely upon the plate—as when supplying front teeth where the gum has fallen away after the extraction of the roots, or as with bicuspids and molars, which, not occupying a conspicuous position in the mouth, are generally fitted in this manner—the fitting is easily accomplished. In most partial cases, however, and in many complete sets, the teeth are required to fit the *gum ;* and to effect this it requires some skill, for while the front part of the base of the tooth must fit accurately to the gum, the back part must fit accurately to the plate. The first point, then, is that the latter must be cut along its gum border so as to lie *within* the line along which the teeth are to be fitted to the gum. It is usual in such cases to cut the plate—guided by the eye only—to what upon comparing the bite with the shape of the gum seems necessary. Then one of the central teeth is ground at the lathe (Fig. 48), until the proper length and position as indicated by bite,

&c., is obtained, and so on with the others. But it is impossible in the first instance to cut the plate by the eye, so as to give it exactly the outline and position required. So that we find as the fitting of the teeth proceeds it is frequently necessary to interrupt the work in order to accommodate the plate piece-meal to the more correct outline as indicated by the advancing tooth. This is a tedious method, resulting occasionally in awkward mistakes, frequently in rough, imperfect fitting, and always in loss of time. The plan we have adopted and long practised is the following.

Fig. 48. Lathe for grinding Mineral Teeth

Fit the teeth at first by themselves to the model without the complication of the plate. Colour the plaster gum with rose pink, and fit the teeth accurately to it, to the proper length and position as indicated by the centre line, bite, &c. This is a very simple operation, for the plate not being on the model there is no complication, and the atten-

tion is not divided. As each tooth is fitted it is secured to the model behind with cement. When all are thus fitted and secured, go round the fitting edges with a fine needle point, leaving on the plaster gum a traced line exactly representing the position of the fitting teeth, also draw straight lines from between the teeth out upon the model. Upon removing the teeth and the wax, it will be at once seen (Fig. 49) that we have unerring guides for cutting the plate at one operation. It must be cut so that its gum border shall lie about an eighth of an inch within the festooned line. Putting the plate on the model, the straight lines drawn from between the teeth at once show—however much surplus plate there may be—the points where the deep cuts are to be made. As these are made on the plate, the traced line on the plaster shows itself, and by it the complete reduction is accurately and quickly accomplished. Now matters stand thus: the teeth are perfectly fitted to the gum over the front half of their base, and the mind pencils off that part as not to be touched again by the corundum wheel; all that is required now is to colour the edge of the plate, and grind carefully from the back part of the base of the teeth the little that is necessary to permit them to settle down to their traced marks on the gum.

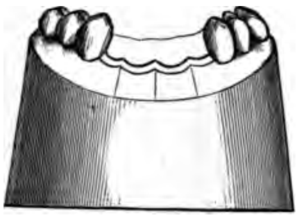


Fig. 49. Model with Traced Lines, showing the best method of fitting teeth to plate and gum.

The advantages of this method are best observed

where the clasps form a further complication; also in those cases of large uppers with irregular gums where there is an uncertainty as to which teeth should fit the gum and which the plate. In such cases this point can be at once settled satisfactorily when they have been fitted as described and the effect observed. The teeth may be backed either before or after their second fitting.

Backing Flat Teeth.—They must first be cleansed from the wax adhering to them, and their pins straightened or made parallel to each other. The ends of the pins of each tooth are then tipped with colour, and a strip of plate is laid steadily against

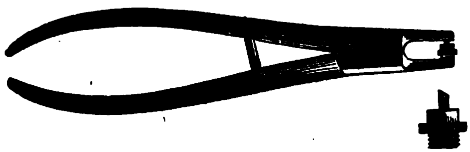


Fig. 50. Perforating Pliers.

them. The colour marks thus left on the gold indicate where the holes are to be punched by means of the pliers represented by Fig. 50. Fig. 51 shows a perforating tool introduced by Dr. Mallet, by which both holes may be punched at once, one of the perforators being movable, so that it can be adapted to any distance from the other which the positions of the pins of the various teeth may require. The strip of plate is then placed upon the tooth, and the outline of the required back taken; the latter is then cut, dressed with the file, and fastened to the tooth. This last may be effected by riveting the pins or by splitting them.

Riveting is best done upon a lead block—a counter for example—and the surface upon which the face of the tooth is laid must be clean and flat, or *very slightly* concave. The pins are cut to such a height only above the back as will ensure a good rivet head. Tight riveting must not be practised; there is no necessity for this, since the solder *fixes* them to the back, and a tightly riveted tooth when put through the fire is liable to *crack*, owing to the expansion produced by heat. Backs may also be fastened sufficiently by splitting the

Fig. 51. Perforating Pliers (Dr. Mallet's).

platinum pins, and we think this to be the preferable method. A rivet head may sometimes be run over by the solder without the latter taking effectual hold of it, thus leaving the tooth apparently soldered, but really depending altogether upon the rivets. This is scarcely possible when the other plan is adopted. The pins having been cut almost flush with the back, the holes in which should be slightly countersunk, are split with a small square edged tool. The cut must be made across the middle of each pin, and only to the depth of the

countersink. A careless split made with a graver breaks up the platinum and leaves the pins without strength. The teeth—which are now supposed to fit accurately in all respects to the plate and gum—are replaced in position and fastened to the plate with the cement. The case is now ready for inserting into the investing mixture. This is made by combining plaster with either sand, pumice, or asbestos. Or sometimes plaster forms the one part, while equal parts of sand and asbestos form the other. The asbestos serves to bind the mixture, so that if it be not used one or two threads of iron binding wire should be formed into a skeleton frame to be imbedded in the plaster surrounding the teeth. This may be formed so that one thread will lie under while the other goes round the face of the teeth, at about one or two eighths from their surface. The substances used are mixed moderately thick with water, and poured into suitable shape upon paper laid on the bench; and the plate is imbedded so as to cover its lower or palate surface, bringing the material up in front of and enclosing the cutting points of the teeth. If the wire be used as a binding frame it must be imbedded at this stage. It is of importance that there should be as small a quantity of investing material about the plate as possible—this is a point which has a direct bearing upon the warping of plates—in the case of broad uppers, therefore, the palatal surface should be left to a great extent uncovered by it. In front of and under the teeth the mixture may be from two to three eighths thick. In partial cases the investient must be kept at its full

strength over all spaces which occur between groups of artificial teeth, otherwise it will crack at these points and the adjoining teeth will be displaced. In cases, too, where the teeth are fitted to the plate, which extends more or less beyond their necks, care must be taken that the investient is left of full thickness along its border for the same reason.

The next step, when the plaster has set, is to clear the wax cement from the backs of the teeth and joints; after getting the cement away in block (which is done by applying the small gas jet to the edge of the plate), boiling water may be used so as more thoroughly to cleanse the joints.

All parts to be soldered are then scraped, borax applied, and any joint not perfectly close must be packed with a small cutting of gold. The solder is arranged along the joints and over each pin, and the case is then dried, slowly at first, lest the borax should swell and displace the solder. The drying may be completed over the bunsen, and the case at once heated up by the blowpipe and soldered; but the usual and perhaps best plan is, after it is dried, to place the case in the fire (or stove) and heat it up to a low red before soldering. When the heat of the plate is brought up by the blowpipe a strong blue-white flame is used first over the investing material. When plate and plaster are brought to a red heat the pointed white flame is made to beat in the neighbourhood of, rather than on, the solder; when the latter begins to give way the flame is sharply turned upon the solder, and thus the operation should be satisfactorily accomplished.

There are cases, however, where special difficulties are met with; such, for example, as have detached teeth to be soldered, the joints of which lie in a deep recess, with high clasps on each side. Here the difficulty is to solder the joint without melting the clasp. Sometimes a morsel of plaster or pumice-stone placed against the clasp will effectually protect it, and direct the flame to the point to be soldered. But the best plan is to use a slightly inferior quality of solder for the most difficult joints —Ash's No. 3, for example, the clasps having been soldered with No. 2.

In these cases, also, the investing material and the main plate should be heated very highly—keeping the flame from the clasps—before turning a very pointed flame upon the joint.

The case having been soldered is allowed to cool gradually before taking it from the investient. It is said that this gradual and thorough cooling is necessary in order that the teeth may be properly tempered, as with glass, taking them from the investient while hot, leaving them brittle. The plate is then placed in the cleaning acid, or "pickle," which if heated will act much quicker in cleaning the surface of the gold and dissolving the vitrified borax adhering to it.

Warping of Plates.—When placed upon the model, the plate which has just been soldered is found to have more or less altered in fit. It grasps (if it be a large upper) along its outer edges on both sides of the model, and it is open along the line of the palate. The gold, in common with other metals, expands when heated; but when that natural ex-

pansion is not interfered with—as, for instance, in the earlier stages of construction—no change of fit occurred in consequence. But when the plate is enveloped in plaster, free and therefore harmless expansion is impossible; the metal still expands, but it does so in an irregular manner—becomes distorted, or warped. The shrinkage of the solder after setting is spoken of as possibly helping the warp by drawing the plate; the other, however, may be taken as the main cause. In our own experience we have found that the best results are obtained by limiting the quantity of investing material about the plate to the smallest dimensions, consistent with a proper holding of the teeth and plate together; by this means the warping may not be got rid of in all cases, but the evil appears seldomer and is of less extent when this plan is employed than by any other with which we are acquainted. It has not been explained how the copper frames,* or saucers, recommended as a means of preventing warping, *act* for this purpose; but the idea seems to be that they will in some way still further bind the plate and prevent its expansion.

If the theory stated above be correct, it would appear that the plate is bound too much already, and that any further binding can only increase the evil. It is doubtful, however, whether these frames have any direct influence upon the plate one way or the other; and the objection to their use arises

* These are strips of copper plate bent into oblong or semi-circles of various sizes; they are filled with the investing material, and the denture is then imbedded.

more from the fact that by employing them a quantity of investing material is made to surround the plate, quite unnecessary for the purpose of holding the teeth, and which adds considerably to the chances of warping.

Finishing.—The finishing of a plate is frequently made unnecessarily difficult by a careless use of the file during its construction. The latter should be used with precision, so that only those points which *must* be reduced are touched by it; a few careless slips of the file leave marks which can only be effaced by expending much time and labour which would otherwise have been unnecessary. Again, the blowpipe should be used so as to leave the joints of clasps and teeth with a perfectly smooth and well-shaped surface, requiring neither file nor graver to be used upon them.

Many dentists disapprove of giving a high polish to plates, and consider it sufficient if they are well made and smooth. In such circumstances the method adopted is to stone the filed edges and go over the general surface with the polishing stick and damp pumice, after which they would be considered finished sufficiently well for inserting in the mouth.

Where a high polish or "shine" is required to be given in a short time, the "skin," always found upon gold at this stage, must be taken off by means of the scratch-brush, or by using a carefully sharpened graver, to lightly scrape the surface, as is done in finishing vulcanite cases. Water of Ayr stone, cut to different shaped points, must then be used over the surface, moistening the

cutting points frequently with water; a quick light motion of the stone is most effective. Sometimes pumice-stone, cut into pencils, is used instead of the Scotch stone, but the latter is generally preferred. When the file and graver marks have been effaced by these means, the plate is taken to the polishing lathe so that the marks of the stone in turn may be effaced. For this purpose the circular hair-brush is charged with ground pumice moistened with water, oil, or molasses; the two last keep the abrading material to its work more effectually than the water. While it is being polished at the wheel the plate should be kept in constant motion, and where there are clasps these should be protected by the fingers closing over them, otherwise they are liable to be cut and disfigured by the wheel. After the pumice has done its work the plate must be thoroughly washed; the polishing is then completed on the rouge-wheel, which is at first used damp, the polishing material, well mixed with water, being added to the plate and brush; the latter is at last used dry, and revolving at a higher speed.

For those parts of the plate which the wheel cannot reach, pieces of soft wood charged with the polishing materials may be used. Some dentists do not use the scratch-brush or graver to take the "skin" off the gold; but in that case one must either be content with an inferior polish or much additional time must be given to the stoning process.

Tube Teeth attached to Gold Plates.—In those cases where the teeth are required to fit the

gum, or as in upper sets where some are to fit the gum and some the plate, the same method should, to a certain extent, be adopted as that which has been described in connection with flat teeth. There are two points, however, which should be remembered. The tube teeth when fitted, in the first instance without the plate, to the model and bite, should be left sufficiently long to allow for fine fitting when the pins are soldered. And again, the gum border of the plate must be reduced with relation to the position which the "pins" must occupy, as well as to the traced line on the model. For instance, the tubes of many incisors (Ash's always) are quite close to the front border of the tooth where it fits the gum, so that unless the plate is left as "full" as the traced line itself, the pin could not be inserted in its true position. In such cases, after having rough fitted the incisors to the model alone, it is generally advisable to cement them to the plate and take the position of the pins, leaving the operation of cutting the gum border of the plate until the pins are soldered, when it can be done readily and without risk.

The plate having been replaced on the model, the teeth—the tubes of which must be cleansed of the débris of platinum and mineral left by the corundum wheel—are cemented to it in accurate position, and the places for the pins ascertained by passing a wire, tipped with rose-pink or vermilion, down each tube; this leaves colour marks on the plate which indicate exactly where the holes must be made for the insertion of the pins. The wire used for *marking* should be carefully made and

preserved for this special purpose. It may be made of iron or steel wire, and should fit the tube easily, but not loosely, and the marking end should be filed or ground to a *true point*. A flat-ended wire is sometimes used, but a moment's consideration will show that such a marker must give uniformly false marks. For the teeth being set upon a plate with a more or less inclined surface, the flat-ended wire will, when passed down the tube, touch the plate with some part of its circumference; but the mark thus given will be taken as representing the centre of the hole to be pierced, and the pin when soldered will be found more or less out of position. Therefore a carefully pointed wire as first described must be used for this purpose.

The teeth having been carefully removed from the plate, the next step is drilling the holes. First a slight countersink is made at the centre of each colour-mark by a suitable edge tool; this gives a catch to the drill, which is then made to pierce each hole in succession.* This will be best accomplished by keeping the plate on the model, and the drill must act in the line required for the position of the tooth. The one used is generally smaller than pin size, so that the broach, while widening the hole to the required size, may at the same time correct any error in direction or angle which may have been given by the drill. The rough edge left on the plate by the drill and broach must then be taken away, and the pins—the ends of which have been cleaned by the touch of a file or graver—are

* Perforating pliers should never be used for this work, as they bend the plate.

inserted by the aid of pliers. They must not be wedged too tight or the solder will not run through, but just tight enough to retain the position they are placed in, during the soldering process. The joints are then treated with borax solution and soldered. The solder is generally applied on the upper or lingual side of the plate, but in some cases (between clasps for example, or in deep hollows) it is more convenient to solder from the inside of the plate. Very small pieces of solder must be used for this work; the broad blue-white flame is used to heat up with, and if the plate be well heated in this manner the solder will flow

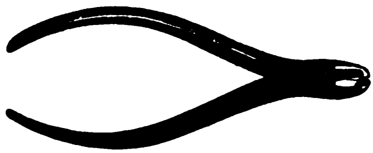


Fig. 52. Cutting Pliers.

perfectly; the charcoal support should be moved in such a manner that the flame shall act on all parts of the surface, and also partly underneath the plate, so as to *draw* the solder through. After soldering, the ends of the pins on the inside must be reduced to the level of the plate; this is done with small beaked cutting pliers (Fig. 52) and gravers; and sometimes the pins are then flushed on the inside surface by a second soldering, but this is unnecessary if the solder has been drawn through —as it ought to be in all cases—from the one side of the plate to the other.

Another method of drilling the holes for the pins

may be mentioned, which does away with the necessity of marking, and by which the drill must take the direction required by the tooth. The teeth, having been cemented to the plate, are then surrounded with plaster in sufficient quantity, and formed round teeth and plate in such a manner, as to retain them fixed in position while the drill itself passes along each tube, and at once pierces the plate. The drill used for this work must be carefully pointed, and must be easy in the tube without being loose.

The method first explained will, if properly worked, give perfectly accurate results, and is to be preferred to the other, in our opinion, as having fewer risks. Where there are a number of teeth, it will be found a good plan to solder one or, perhaps, two pins, and get them accurately in position; these then furnish a guide for inserting all the others in the one operation. We next proceed, after they have been soldered and ascertained to be perfectly placed, to fit the pins accurately to the bite. The plate is placed upon the model, and the pins are cut and filed as the bite touches until the latter is quite home and the articulation exact.

This plan not only allows us to get *at once* done with the pin-cutting, but it affords us a certain guide for the fitting of the teeth, to which our attention is now wholly directed.

The incisors (supposing the case to be a complete upper) must of course be fitted not only according to bite and gum, but their length, or the extent to which they should close *over* the lower incisors must depend also upon whether the patient

shows the teeth much or little. The bicuspids and molars,* on the other hand, depend altogether upon the bite and plate; and as we know that the pins are cut exactly to the required articulation, we may go on with the fitting of these teeth without consulting bite or model until the pins appear at the tops of the tubes. It is often best, however, to contrive that the teeth shall closely fit the plate—fine fit as it is called—before the pin quite reaches the top of the tube. Then the teeth of the *bite* are coloured with pigment, and the artificial crowns ground to a perfect articulation with them.

Swivels.—As a means of retaining sets of teeth in position, swivels and spiral springs are now seldom employed; nevertheless, it will be well here to explain the method by which they are usually attached. They are generally fixed to the plate after the pins have been soldered and the teeth fitted. The positions which the swivels must occupy depend altogether upon the positions of the teeth; they must be soldered to the plate so that the spiral springs, which are afterwards attached to them, shall act in a line parallel with the faces of the molars and bicuspids, and as a rule close to these surfaces. Otherwise the position chosen for the swivels should be that which will best balance the set. Between the bicuspids is, perhaps, the average place given to the upper ones, and the lower are placed exactly below the upper, or *very*

* These teeth are usually only fitted in the first instance sufficiently to sit steady on the plate while the positions for the pins are being marked; the bulk of the fitting therefore takes place after the pins are soldered.

slightly forward. Four pieces of plate must be cut —about one-eighth square, or a little over—a hole is punched through the centre of each, and made of such a size that the swivel-bolt will go tightly through it. These are the "cheeks," or standards, which must be soldered to the plate, and against which the swivels are to work. The standard is placed in that position on the plate, and against the teeth, which the swivel must occupy, and its lower edge is filed if necessary to fit the irregularities of the plate; marks are then made upon the latter with a sharp point, so as to take the exact position of the standard, so that when the teeth are removed it may be replaced accurately upon the plate and soldered. The teeth are then taken off, and a cut made with file or graver point along the line where the standard is to be fixed; this gives a catch which prevents the latter from slipping while tying it for soldering. A thread of binding wire is then passed through the hole in the standard, which is then placed in position and bound down tightly with the wire. This should leave it lying flat upon the main plate; and now by raising it gently to its proper position the strand of wire will tighten and fix it sufficiently for soldering (Fig. 53). For this of course the joints should have been prepared in the usual way, and the flame and other directions given for soldering the pins will be suitable for this work.

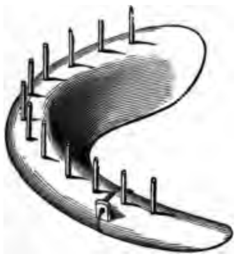


Fig. 53. Upper Plate with "standard" tied, ready for soldering.

It is a good plan to "tack" the standard first with one small piece of solder; then the teeth should be tried on to test its accuracy of position, which can be easily corrected if found slightly false in angle. The soldering is then completed, using a thread of wire as before; and a very small piece of pumice-stone or coke will be found most useful if placed at the back of the standard, for binding against and preventing it from falling back upon the plate during the soldering. Now the swivel and bolt are to be passed through the hole, and the bolt soldered at the joint at the back of the standard; but if that was done without further preparation, the solder would most likely pass through from one side of the joint to the other, and "fix" the swivel. To prevent this it is not sufficient to work in whiting from the circumference of the swivel after it has been inserted in the standard. *Before* inserting it, whiting made into a thin paste with water must be carefully coated over the surface of the swivel and joint which is to come into contact with the standard; these parts may then be inserted, and the joint at the back of the standard should be scraped and touched very slightly with the solution of borax. Fig. 54 represents a swivel with bolt of full length; also one with bolt cut, for insertion into standard; the third cut represents the swivel without bolt. The solder having been placed, the plate should be well heated up, and a pointed blue-white flame used to reduce the solder. Such is the method which will be found

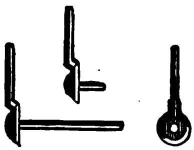


Fig. 54. Swivels with Bolts.

most suitable for the majority of cases; there are others, however, where different treatment is necessary, as, for instance, where the hole for the swivel-bolt must be pierced through the main plate; but the points already noticed indicate generally the essential considerations.

Fastening Tube-teeth to the Plate.—The plate having been "pickled" and "stoned," is then ready to have the tube-teeth fixed upon it. To accomplish this properly the tubes must be made thoroughly clean, and the pins on the plate should be scraped and "barbed," or roughened slightly with a graver edge. The teeth are then put on, and the plate, being held in the pliers, is heated carefully over the bunsen flame; sulphur (in powder) is then placed at the top of each pin, and if the plate has been properly heated the sulphur will melt and flow down the tube and pin; the case is then allowed to cool, and the teeth will be found thoroughly secured. Another method, and one it is well to adopt in certain cases, is to heat the plate over the bunsen flame *before* putting on the teeth, and give each pin a coating of sulphur; the teeth are then heated one after the other over the flame to such a degree, that when placed upon the pins their own heat will melt the sulphur, as they are passed over the pins. This requires a little more time than the other method, but it is very certain in its results.

CHAPTER VIII.

VULCANITE WORK.

Complete Sets.—Shallow plaster models having been cast from the impressions taken of the mouth, it is then necessary to obtain the "bite."

In order to obtain perfectly accurate results, a rigid base plate is required on which to mount the biting-blocks. In the work just left the gold plates themselves answered admirably for this purpose; but in the construction of vulcanite sets the only plate available is one of wax or gutta-percha, and neither of these by itself is able to resist the force exerted upon it by the patient in biting. Some strike Britannia-metal plates—thickness of modelling wax—for the models, and upon these set the biting-blocks, and afterwards the teeth. The time required for preparing these plates is the great objection to their use; otherwise they answer the purpose well.

Perfectly satisfactory results can, however, be obtained in a few minutes by the following method. Damp the surface of the plaster model well, and make a gutta-percha plate upon it, extending over the palate. Then take an iron wire (pin size) of

suitable length, and bend it to fit across the floor of the palate, with its ends extending up and over the alveolar ridge, at the point to be occupied by the first or second molar. The wire is next heated over the bunsen and sunk in position upon the gutta-percha, which being softened along the whole line by the heat thus imparted to it, can be at once closed over the wire with the finger. The plates prepared in this manner will be found perfectly rigid in the line along which the force in biting is exerted. The wax biting-blocks are mounted upon the gutta-percha plates, and the bite is taken, and cast in plaster in the manner already described in connection with gold work.

When the plaster bite has been "taken off," the gutta-percha plates are then removed from the models, which must now have wax plates made for them, and upon these the teeth are set. In softening the modelling wax for this purpose care should be taken not to melt its surface, and in closing it to the model very slight pressure should be employed; otherwise the uniform thickness which we desire to reproduce in vulcanite will be destroyed. When adding wax for supporting the teeth to a higher level than the plate itself would give, or afterwards when modelling up the piece to the desired outline, it is much better to use softened strips of wax, where the additions are required, than to drop melted wax upon the plate until the height and shape is obtained. By the latter method not only is time lost, but too often a clumsy ill-made piece is the result. By the former we can at once attach to the plate a skeleton frame of soft

wax in which the teeth may one after the other be placed to the required height and fulness, dropping wax behind each as its true position is obtained. This will also be found to be the best means of obtaining a *shapely* piece.

Before setting the teeth their pins must be bent in such a manner as will best keep them firmly fixed in the vulcanite; and the pliers used should have such surfaces as will *roughen* the pins while bending them. For the more effectual holding of the pins, instead of bending them, cross wires of platina are sometimes soldered to their extremities; but this practice need only be adopted in very exceptional cases. The pins, of the length and strength which is usual among the teeth of the present day, are well fixed in the vulcanite by bending as described, and having the surfaces clean while packing. In the case of a complete upper and lower, the lower teeth are first mounted accurately in position, using the wax-block on the upper model as guide. This block has been cut when taking the bite to the exact fulness required for the case, and if the lower teeth are set so that their points will come slightly within the face of the upper block they must be correct. When they are fastened in position, and the wax is modelled up to the required form, the upper teeth are then set to the lowers. The centre line must be carefully worked to, and the points of the upper incisors must be made to close over the lowers, while the bicuspids and molars should be made to fit well to each other, grinding their crowns if necessary. It is most important that there should be a good

articulation; where the bicuspids can be got to "lock," or close *between* the opposite crowns, this may readily be obtained; but where the cusps close perpendicularly upon each other, considerable grinding of the surfaces will be required. "Locking" may often be obtained by a slight spacing of the incisors which may allow the cusps of one set to close between the cusps of the other.

Swivels.—If swivels are required for a vulcanite set, they may be inserted either after the case is vulcanized and finished, by drilling through the vulcanite, or they may be inserted at this stage, viz. when the teeth have been arranged and the wax modelled into the required form. If the latter plan be adopted, the "bolt" of the swivel need not be left over a quarter of an inch long, and it should be *barbed* with a graver;* and when it is inserted into the wax it should not be heated but pressed in cold, otherwise some trouble may be experienced from the loosening of the swivel in the wax. By adopting this method, springs may be attached to the swivels for trying the case in the mouth if care be exercised. This plan of trying in a set with springs attached is regularly practised by some dentists, whether the case be ultimately intended to have springs or to be without. A special set of swivels is made and reserved for this purpose; their "bolts" are fixed into square

* The bolts are sometimes crushed between the jaws of the "vise," but this is a plan which cannot be recommended. A slightly barbed bolt holds perfectly in the vulcanite, and should it be necessary afterwards to extract it from the latter, that can be readily accomplished; not so if the other method of roughening be adopted.

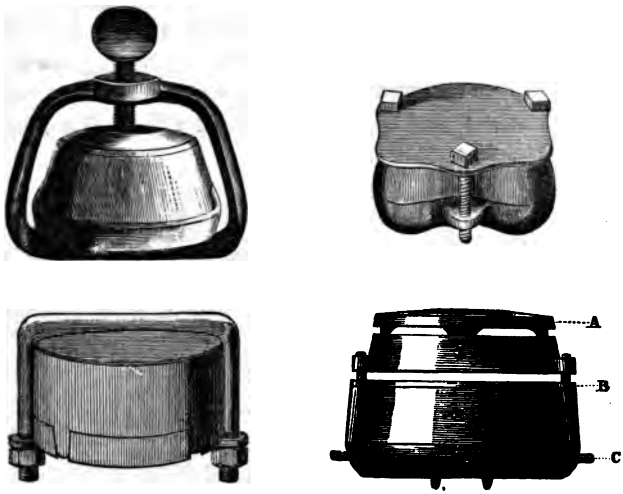
pieces of wood or gutta-percha, which gives them a good hold in the wax. They may be inserted in the *biting-block* after it is pared to shape, and thus an additional help be secured towards obtaining a correct bite.

Firing Models.—Upon these the cases are "flasked," packed, and vulcanized. The first or original model may be used for this purpose, or a second one taken from the original may be employed. The usual, and perhaps the best, practice is to use the original for firing upon for all edentulous cases; but for most partial cases the other method is adopted, the original model being retained for use after the piece has been vulcanized. The firing models must in all cases be made shallow; and where the artificial teeth are *long*, the case and model should be tried in the flask before mixing the plaster, to make certain that the points of the teeth are ranged well below the border of the upper half of the flask. The cases are cemented to the firing models by a hot knife used round the plaster and wax border.

Fig. 55. Set of Teeth on Firing Model.

Should a "chamber" be required for a suction upper, the "shape"—which may be made of lead, &c., the thickness of modelling wax—is cemented to the upper (lingual) surface of the wax plate; but after separating the flask, and before packing, it must be fastened in position on the palate of the model.

Flasks.—These may be had in a great variety of patterns, but they may be generally described as consisting of two kinds—first, those which are made in two main parts or chambers; and second, those made in three main parts; in both, a lid, which may be considered the third and fourth parts respectively, completes the flask. Fig. 56 shows a flask of the



Figs. 56, 57, 58, and 59. Vulcanizing Flasks.

first description, the parts being fastened together by a clamp. Fig. 57 shows a flask of the same kind made by Whitney, in which the parts are secured by three screws. Another method of fastening is to use a simple stirrup or narrow metal band, which is tightened upon the flask by inserting an iron wedge. In Fig. 58 we have one of a very useful description largely employed by dentists.

Fig. 59 represents one made according to the second principle, having three parts and lid; this flask was introduced by Messrs. Bell and Turner.

The first kind (those having two parts) are used where the model and teeth are to be held in different chambers of the flask, the vulcanite being packed in the upper chamber (containing the teeth), which is then closed upon the lower which contains the model. The second kind are used

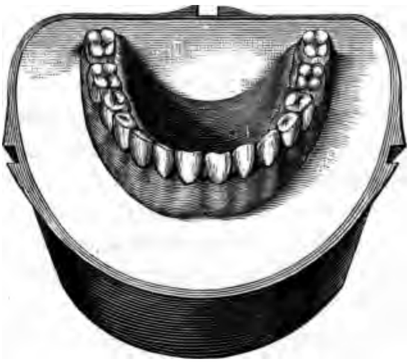


Fig. 60. Upper Set imbedded in lower part of Flask.

where teeth and model are to be held together in the *same* chamber, the vulcanite being packed in such cases directly upon the model. Both flasks are required in the work-room, for though it is certain that the best results are obtained in nearly all cases by using the latter description, the others may occasionally be used with advantage for new work, and they are the most convenient for *repairs*.

The two-part flask is worked in the following manner. The bottom chamber is two-thirds

filled with thickly mixed plaster, and the firing model is at once sunk in it, the plaster being brought up to the edge of the wax, from which it slopes down to the border of the flask, which must be left clear, so that the upper part will close perfectly upon the metal of the lower. The plaster surface must be made smooth and well oiled or soaped, the teeth being left untouched. The filling of the second chamber requires great care, so as to avoid the "blows," or air cavities, which may form about the teeth, and may be the cause of their changing position. Sufficient plaster having been mixed to fill the flask, some of it is taken up on a tooth-brush and rubbed thoroughly over all parts of the teeth and gums, when a thicker coating may then be quickly applied; the second part of the flask is next put on, and the chamber is completely filled with plaster, and the lid pressed down into position. This manner of filling a flask will effectually prevent the faults referred to, but some quickness of action is necessary, so as to finish the work before the plaster becomes too thick. When the latter is set, the flask should be slightly warmed, and the parts separated by prising at opposite parts of the joint. Before removing the wax, its form and outlines should be noted, as the recollection will assist the manipulator when afterwards disposing the vulcanite in packing. Boiling water is used to remove the wax which may not be readily taken away with a knife. Grooves may now be cut in the plaster with a graver, from the borders of the flask up to the model. These "gates" are provided so that any excess of vulcanite shall readily

escape, and not interfere with the closing of the flask after the packing has been completed. It will be found, however, much more satisfactory to take some trouble to ensure that only the proper quantity of vulcanite be packed into the mould. With the most complete supply of "gates," if there is much excess of rubber the case will be a failure, and with careful packing the "gates" are scarcely required. The flask must be heated before commencing to pack; this may be done by steam or by dry heat. If the former is employed, the flask should not be allowed to lie surrounded by the water, but should be raised, so that only the steam will act upon it. But whichever plan be adopted, the heating should be carefully attended to, and whenever the flask reaches the point beyond that which can be well borne by the hand, the packing should be proceeded with. *Overheating*, either by steam or dry heat, *completely destroys the plaster*, so that when the least pressure is employed it gives way, and the success of the case is endangered.

Preparing the Vulcanite.—First, as has been already stated, it is most important to pack the case with *just* the quantity of vulcanite required. This quantity may be found by weighing the wax —which must be taken from the mould in a very complete manner; then by knowing the respective specific gravities of wax and the vulcanite used, we are enabled to find the quantity of vulcanite required to fill up the space before occupied by the wax. For example, the specific gravity of wax is 0·96; and Professor Austen states the specific

gravity of American red rubber as 1·572. Hence to fill the mould when pure wax is used for a

Fig. 61. Glass for ascertaining the amount of Vulcanite required or any case.

model plate, it will require to 1 part of wax by weight 1·6 of the red rubber.

This plan is not, for obvious reasons, a very

convenient one to adopt. A readier method is to obtain at once bulk of vulcanite for bulk of wax. This is done in the following manner. A suitable glass vessel (Fig. 61) is filled to a certain point with water; the wax is then immersed, when the water of course rises to a higher level; this higher point must be marked; the wax is then taken out, and vulcanite is put into the tumbler until the water again reaches the higher level. It will be found much more satisfactory to take this measurement *before* the case is secured to the firing model. Then it represents exactly the bulk desired plus

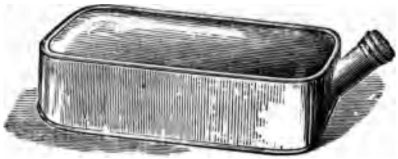


Fig. 62. Heater for Vulcanite.

the bulk of the artificial teeth; and this surplus is required so as to allow for the consolidation of the vulcanite in the "press." For the above purpose a graduated glass is most convenient, but a common tumbler and colour marks may be used.

The vulcanite is then cut into pieces most suitable in size for the case in hand. Narrow strips must be provided for packing round the pins of the teeth, and the pieces increase in size as the work proceeds, large squares being used for the broad palate of an upper. The most convenient heater for the vulcanite is a tinned iron or zinc box about an inch deep, containing water, and fixed so that

the flame of a bunsen may be applied below to maintain the heat.

Packing.—The upper part of the flask, or counter, as it may be called, in which the packing is done, should be well wrapped round with a towel before commencing operations; this will in great measure preserve the heat. The narrow strips of the "base" rubber are first packed below and round the platina pins; then the smaller pieces of gum are packed between the teeth, and the larger used to complete the "facing." The surface left upon the gum rubber should be continuous or solid; if joints are left over the surface, such as those made by pieces imperfectly packed together, the red rubber will come between, and probably appear through the facing of gum when the case is finished. The packing of the "base rubber" is now proceeded with in the deep parts of the mould at the back of the teeth, and from this point the work may be done more rapidly; over the palate of a suction upper the large squares of vulcanite are simply placed in position, the pressure afterwards employed being sufficient to consolidate the parts.

Packing will be found a simple enough process if it is commenced with a sufficiently hot mould, and if the operation is finished before the latter becomes cold.

To ascertain the condition of the work after closing, a piece of damped cloth * of sufficient size is placed over the vulcanite after packing; the parts are then put together and the flask placed in

* That found between the sheets of vulcanite is very suitable.

the press or vice, where it is closed by a gradual and equal application of the force. It is then separated carefully and the cloth removed; any difficulty in regard to the latter may be readily overcome by thoroughly damping the adhering parts. Should there be a deficiency of vulcanite, additions must be made to the defective parts; should there be an *excess*, that is removed by using a hot knife. When the faults have been corrected the flask is perfectly closed in the press; it is then fastened by its clamp and vulcanized.

Fig. 63. Press for closing Flasks after packing.

The second kind of flask—that having three parts—is generally used for those cases in which the model and teeth are enclosed in the one chamber and held together by the one plaster. The first and second parts of such a flask when put together should form a chamber large enough to receive any firing model with the denture attached, and the superior border of the metal should be higher than the points of the artificial teeth. This chamber having been more or less filled with plaster,* the firing model and denture (the teeth of the latter having been brushed and coated with plaster) are

* The quantity of course depends upon the dimensions of the case to be imbedded, but it is better to mix an excess of plaster rather than a deficiency.

imbedded in it, so that the points of the artificial teeth shall lie slightly below the metal border; as the case is pressed down into this position the plaster rises up over the teeth, the crowns of which should also be covered with it. Thus the only part of the case left exposed is the lingual surface of the wax plate. The plaster must have a surface favourable for parting; and when it is set and thoroughly oiled or soaped, the third part of the flask is put on and filled with plaster, and the lid pressed into position. The "two-part flask" might be used for working upon this plan, but its lower chamber is so shallow that the teeth stand high above its border, and the plaster, which must therefore be brought up over their faces and points, is unsupported by metal, and very subject to break in a serious manner both in packing and closing the flask. If this flask be employed, however, its order of parts should be reversed; make the lid and upper part together the bottom chamber, into which, it being filled with plaster, the case is imbedded; the bottom part may then be used as the new upper chamber and lid in one.

Fig. 64. Three-part Flask.

For many years we have used one somewhat similar to the "Bell and Turner" three-part flask, and find it most convenient for this kind of work. The accompanying figures explain themselves. In Fig. 65 we see the chamber (1, 2), with the protect-

ing flange round the superior border of the arch—in which the case is imbedded. It is rather smaller in size, and wants the details of fixing pins and diaphragm and "bottom ribs" of that flask, and

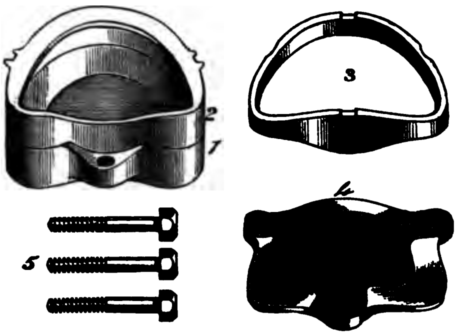


Fig. 65. Three-part Flask.

the arch of the superior border of the second part is formed into a narrow flange, which gives additional strength to the plaster covering the teeth, the points of which when the case is imbedded are ranged under it. Fig. 66 gives a view in section of this flask with a case of teeth in position.

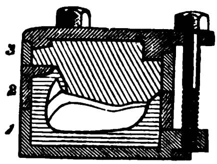


Fig. 66. Three-part Flask in section.

The "Contour flask" we have used, but found the arrangement for packing and pressing from behind a very inconvenient one; it is, however, very highly spoken of by several dentists.

The details already given in connection with the packing process sufficiently indicate the essential points to be observed in all cases. In the present

instance the packing is of course done in that part of the flask containing the model and teeth, commencing with the pink or facing rubber which is carefully packed between the teeth and otherwise as the case requires; the packing of the base rubber is then proceeded with and continued as far over the model and palate as the finished case is designed to reach; the damp cloth is then placed over the vulcanite, and the closing of the flask proceeded with in the manner already explained.

This last method of working is in every respect superior to the other. In the great majority of cases a *perfect* closure of a flask is not obtained, and therefore a thickening, or "rising," over the whole surface involved in the closing of the parts is the result. With the two-part flask, as the teeth and vulcanite are closed together upon the model, the teeth are of course involved to the same extent as the rest of the case in any thickening which occurs. This change is most noticeable in partial pieces, or in others in which the teeth were closely fitted to the gum; in these the new thickness of vulcanite below the teeth is plainly seen, and the latter stand much higher than they ought to do both for bite and appearance. In such cases, where the piece is "raised," as it is called, the fault can only be corrected by the unsatisfactory and tedious plan of fitting it down on the plaster model, or by grinding from the points of the teeth themselves.

But by adopting the second method of flasking, the teeth are fixed to the model throughout the whole process of packing and closing; their relation to it, therefore, remains constant and unchanged,

and any thickening which may occur can only affect the vulcanite *behind* the teeth and extending over the palate; this is a change of little consequence, and the thickness can readily be reduced by using the file or graver on the lingual surface of the vulcanite plate. We should, therefore, adopt this plan as a rule on all occasions. There are some exceptional cases where the two-part flask is the better one to use—these are mostly lower sets—but those who have become accustomed to pack on the model will make an effort to do so even in these more unfavourable cases. There are certain sets, for example, where the artificial teeth are set almost if not quite on the plaster gum, and in front of these and over the face of the alveolar ridge it is necessary to pack a considerable amount of vulcanite. It is impossible in these circumstances, even with the thinnest packers we may improvise, to pass the vulcanite through between the tooth and plaster into the space beyond. We should in such a case disengage the teeth from the plaster, and the space may thus be very easily packed; the teeth are then replaced, and the rest of the packing proceeded with.

The three-part flask can be used in another way to overcome peculiar difficulties. Plaster is filled into its first or bottom part only, and the model imbedded as described in connection with the *first* process, the plaster being brought up more or less over the facing wax, but leaving the teeth free; its surface is then smoothed and oiled, and the second part of the flask being put on, plaster is filled round and over the teeth, as described for the *second* pro-

cess, leaving the lingual surface of the wax plate clear. This plaster surface is in its turn oiled, and the third part having been put on, the flask is filled with plaster and the lid pressed down. Thus it can be separated at both joints, and the case packed at all parts. This mode of working, however, is not without difficulties of its own, on which account it is avoided as much as possible.

Partial Cases in Vulcanite.—If the artificial teeth are required to fit the gum, the same practice may be adopted as with plates; having fitted and arranged the teeth on the model, the modelling wax is then softened and pressed to the latter, bringing it up to join that which fastens the teeth, and fusing the joint with a hot knife. If it is necessary to remove the case from the model, the removal should not be attempted until the wax is quite set.

Clasps.—These may be made from "band gold," and fitted to the teeth in the same manner as that described in connection with plate work. The same care must also be taken to allow them to have ample freedom of action along the holding surfaces of the natural teeth; let them also be as high round the walls of the latter as possible. Broad, thin, and freely acting clasps are the most satisfactory of all. The catches soldered to hold them in the vulcanite must be attached so as not to prevent the required elasticity, and at the same time so placed that they shall be well imbedded in a sufficiently strong part of the vulcanite. For example, the double bicuspid clasp, acting on both sides of the tooth, should have its catch soldered only over a small part of the back of the clasp for the first reason, and as

near the gum border as possible for the second. They should be made of stouter plate than that from which the clasp is made, and should be soldered *strongly* to the latter. The most convenient and generally useful catch is a small piece of plate somewhat triangular in form, soldered so that its base shall lie near the gum and its apex towards the superior border of the clasp. This gives a most effective hold, and from the shape there is little risk of its becoming exposed while "finishing" the piece.

Clasps may also be made of vulcanite, in which case it is of course necessary to mould wax round the teeth, so as to represent in all respects the clasp required. The holding surfaces of the teeth to be covered should be *slightly* pared in the firing model, so that when the case is finished the clasps shall *grasp* the natural teeth. This kind of clasp is seldom used except for large crowned molars. When these teeth stand isolated, the vulcanite can be made to encircle them in the shape of a broad ring, and this is frequently the most effective manner in which a case can be supported in the mouth. The ring should be as broad as the shape of the tooth will allow. In other cases, where the ring cannot be used, the vulcanite clasp should be made to come well round the face of the tooth; it should be made also of the strongest rubber; and a considerable space must be provided between the artificial tooth and the plaster one where a vulcanite clasp is required to come between, otherwise the latter will be in great danger of breaking at that point. When a case of this kind is flasked, if the artificial teeth are covered over as in the second

method of flasking, the plaster must be cleared from the crowns of those plaster teeth which are clasped, so as to expose the superior border of the wax which covers their faces. This is necessary in order that the rubber may be properly *packed* at those parts. Of course this is done before the upper part of the flask is filled.

Fig. 67. Vulcanizer.

Vulcanizers and Vulcanizing.—"It is scarcely to be believed," says Professor Austen, "as we look upon the small copper chambers standing upon the bench in which vulcanizing at present takes place, that the first vulcanizer introduced by Mr. Putnam weighed 1,200 pounds, and required the constant care of an engineer. This was discarded for one of 350 pounds, which in its turn made way for one of 100 pounds, and this was considered the highest improvement of cast-iron vulcanizers."

Those of the present day stand upon the bench, and are only some 12 or 15 inches high over all, and 5 inches diameter; the chamber itself is generally made of copper. The one of most convenient construction, according to our experience, is secured or closed by means of one large centre screw which acts upon a dome-shaped lid (Fig. 67). There is no *valve*, but a fusible metal plug inserted in the lid provides

against all danger of the bursting of the vulcanizer, by melting at from 345° to 350° F.; by standing beside the vulcanizer for three minutes when the heat

Figs. 68, 69, and 70. Hayes's Vulcanizers.

has reached 310° F., and giving strict attention to the rise and fall of the mercury, the stopcock may be so accurately arranged that the mercury will not

vary more than one degree during the whole time allowed for vulcanizing.

Figs. 68, 69, and 70 represent the "iron-clad" vulcanizer introduced by Dr. Hayes for one, two, and three flasks respectively. The boiler itself is made of copper, and it is surrounded by a jacket or sheath of iron; the copper alone, therefore, is subjected to the corroding influences acting within the

Figs. 71 and 72. Whitney's Vulcanizers.

chamber, and should an explosion take place as a result of the thinning of the copper, the iron sheath which has not suffered deterioration remains of a strength sufficient to resist many times the force exerted by that explosion.

The Whitney vulcanizer having space for from one to three flasks (Figs. 71 and 72) is made of wrought

copper, and the lid, which is screwed on, is provided with a fusible metal plug as a security against explosion.

This vulcanizer is favourably spoken of by Dr. Richardson, who has had one in constant use for more than three years without any perceptible deterioration.

Thermometers.—Great care must be observed with regard to these, since the least defect in the

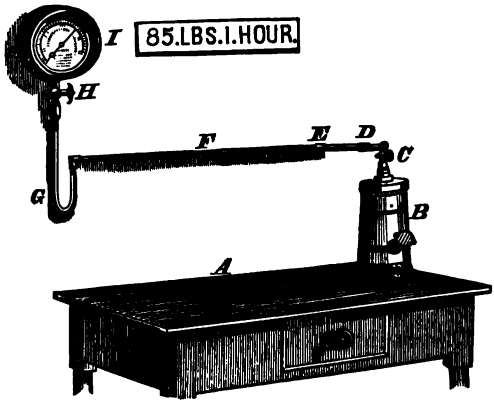


Fig. 73. Steam Gauge for Vulcanizer.

tubes renders the register untrustworthy. "Some time ago," says Dr. Lawrence, "I had some difficulty in producing a desirable shade in my vulcanite work. It was too dark, as is the case when overheated, and I came to the conclusion that the gum had deteriorated in quality. Other samples of gum were tried, and at varying lengths of time, yet with the same result. No defect could be discovered in the thermometer by the naked eye, but a micro-

scope revealed a slight crack in the bulb, and the mystery was solved."

Indeed, so liable are thermometers to derangement, and so readily may their defects pass unobserved, that many dentists prefer to use instead of them the "steam gauge." The accompanying Fig. 73 shows one of those gauges fitted to a Whitney vulcanizer, B; C is a stopcock screwed on in place of the thermometer scale; D, coupling joint; E, angle in the pipe; F, iron pipe three-sixteenths inside; G, U-shaped curve five or six inches in depth; H, cock to the gauge; I, gauge. The descending curve G is provided in order that the steam may be altogether condensed, so that water alone may rise towards H, and act upon the gauge. A pressure of 64 lbs. to the square inch equals 300° F.; 74 lbs. equals 310°; and 85 lbs. equals 320°.

Vulcanizing.—This is a process which demands the most careful attention. The principal point in connection with it, and one which should be thoroughly realised, is, that short time and high heat is ruinous to the best properties of the vulcanite in all cases and the cause of complete failure in many. A disregard of this fact will result in vulcanite pieces which are neither strong nor elastic, and therefore requiring strengthening plates or wires, which are not required in carefully fired vulcanite pieces. Professor Wildman says, "To insure success and produce the best results in hardening any kind of rubber, the heat should be *gradually* raised to the vulcanizing point—not higher than 320° F.—because the best rubber may be rendered worthless by the quick process and vulcanizing at a high

range of temperature." Dr. Franklin says, "If one hour is taken to raise slowly to 300° and another full hour to raise steadily and gradually to 320°, five minutes longer will complete the vulcanizing." This is not a "time" which it would be proper to give in all cases, but it indicates the condition considered by the writer as essential to success. "As thermometers," says Professor Austen, "vary much, and the rubber used also varies, the best plan is for every one to vulcanize trial pieces until the required hardness, toughness, and elasticity is obtained. The vulcanite should curl under the scraper like horn, *permit bending to an angle of at least* 45° *and return to its original shape unchanged.*" Such are the opinions of careful and competent experimenters upon what is required in order to produce the best results in vulcanite work; and the same conclusions must have been forced upon every one who has reflected upon what has happened within his own experience.

The time allowed for vulcanizing must also be proportional to the thickness of the piece and the purity of the rubber. A thick lower made of any of the brown or black rubbers requires the longest time of all. For some of these from one to two hours should be allowed to raise the temperature from 240° to 315°, otherwise such thick cases will be porous or burnt. The same pieces made of gum rubber, on the other hand, may be vulcanized without chance of burning in a much shorter time; that is in consequence of the large amount of earthy matter which the latter contains. Where it is impossible to give the long time required for a thick lower,

it should be made of a gum rubber altogether—S.P. being a good rubber for such cases—or the gum rubber should form the facing and the *core* of the piece, the red forming a more or less thick lining round the lingual surface.

When the flask is taken from the vulcanizer it must be left in water until perfectly cold. The clamp having been removed, a knife may then be carefully used to prise it open at the main joint; the case will generally be retained—opening the flask in this manner—in the upper part; the lid must then be removed; and the best way to get out the piece is to insert a strong-bladed plaster knife between the plaster and the wall of the flask, using the latter as a guide to work against, and send the blade through; repeat this round about two-thirds or three-fourths of the flask, when the plaster may easily be pressed out by the thumb; the cutting away of the plaster from about the case is then very easily accomplished. In taking a case out of the flask in this manner, cut along the back wall first, and be careful in sending the knife through—particularly round the teeth—to keep the blade close to the metal of the flask; if it is *carelessly* entered into the plaster the teeth may be broken. With care, however, this will be found the quickest and safest method to adopt, as a rule, in taking a vulcanite case from the flask.

To cleanse the surface of the vulcanite from the plaster, it will generally be sufficient to brush it well with a strong brush and water. The palate surface of a vulcanite case should never be scraped or cut with a graver.

Finishing Vulcanite.—This is done with files, gravers, or scrapers, sandpaper, and sometimes water of Ayr stone, and the "wheel." The iron-teethed wheels, for "scouring down," which were sometimes used when vulcanite was first introduced, are now entirely abandoned as altogether unfitted for the work of the present day, which if properly constructed requires only the edges to be reduced and the general surface to be scraped.

The quickest and most satisfactory method of finishing vulcanite is by using in the first instance graduated files. The edges of the piece having been reduced, go over the surface with a rough "riffler," next with a medium, and lastly with a fine one. An edge tool may have to be used to trim round the artificial teeth. A most convenient tool (Fig. 75) for clearing vulcanite from *between* the teeth may be made from an ordinary steel pen and holder; one of the points is broken off, and the part of the pen thus left is ground on the corundum-wheel or filed into suitable shape; such a tool will be found most convenient for the purpose, as, from the temper and thinness of the steel, it readily does its work, and if caught or fixed between the teeth no risk is run of the latter breaking, since the tool itself breaks more readily. A file point, sharpened, is sometimes used for this purpose; but this is a dangerous tool to employ, for if it should get fixed between the teeth the latter are easily broken by it. After the fine filing the vulcanite may then be gone over with the sharp scraper, or sandpaper may at once be used; next water of Ayr stone, and lastly the "wheel." The process at the latter

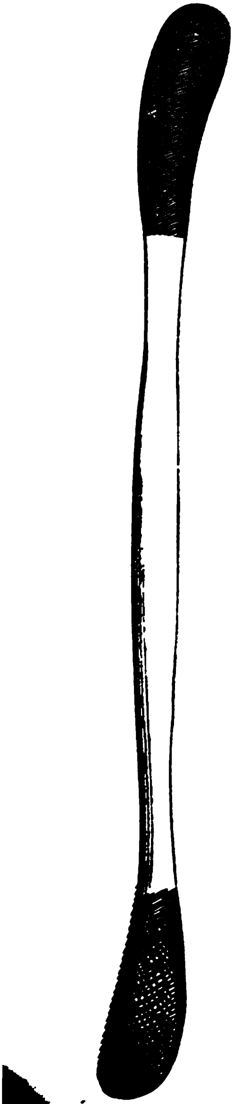


Fig. 74. Riffler.

Fig. 75. Cutting Tool, for finishing between the teeth of Vulcanite cases.

Fig. 76. Scraper for Vulcanite.

is the same as that described for plate, with the exception that, instead of using rouge on the finishing wheel, a mixture of Spanish whiting and rouge, and sometimes the whiting alone, is preferred for vulcanite work.

UPPER SETS RETAINED IN THE MOUTH BY MEANS OF RIDGES.

This method of securing upper sets (complete and partial) was explained by Mr. Evans, of Paris, in the *British Journal of Dental Science* for December, 1874.

On each side of the middle line of the palate, and between the latter and the top of the ridge, a line running parallel with the ridge is found softer than the surrounding parts. This results from the conformation of the hard bone underneath, which along this line is sunk beneath the common level. Mr. Evans takes advantage of this part by attaching ridges to the palate surface of the denture, which after a few hours' wear sink into the palate along this soft line. The accompanying figure shows in section the conformation referred to; *a a* mark the situation of the line along which the ridges should be placed. A wire rather thicker than pin-wire *flattened* represents a ridge which could be used in some mouths, in others a less bold one must be employed. But it is better to make the ridges of full size as they can very easily be reduced afterwards as desired. The part of the palate referred to will be readily discovered by trying the parts with the forefinger.

For vulcanite cases, cuts must be made along the parts indicated, upon the firing model, of the size which is desired for the ridges. For plates, flattened wire may be soldered upon each side of the palate.

Mr. Evans says, "I usually extend these elevated ridges from about the second bicuspid to the second molar (inclusive), keeping them highest in the middle of their length. Of course some practice is required to judge what height of spur can be borne, but they are easily made lower. It might be objected that some of the palatine vessels and

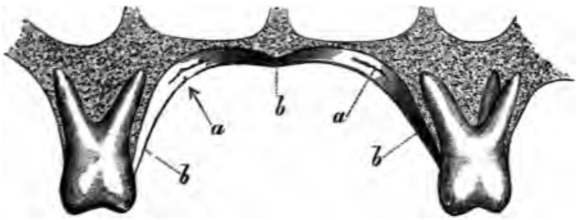


Fig. 77. Section of Jaw, showing the conformation taken advantage of by Dr. Evans for the placing of ridges or spurs upon palate cases.

nerves occupy the groove I have described, and that they might be interfered with, but I have never known such to be the case. And I may further mention, that these plates hold up much better after they have been worn for a day or two." Since Mr. Evans has drawn attention to the practicability of retaining sets in the mouth by this means, many practical dentists have adopted the suggestion, and found the ridge of the greatest value.

CHAPTER IX.

COMBINATION OF GOLD AND VULCANITE.

THIS kind of work may be constructed in one of three ways: 1st, the gold may be struck to the model in the usual way, and be more or less covered with vulcanite; 2nd, the vulcanite may cover the model, and the gold lie upon the lingual surface of the vulcanite; 3rd, the gold may be imbedded in the vulcanite. The following is an example of the first style. A gold plate is struck as explained in connection with gold work, and when it has been perfectly fitted to the model gold "catches" are soldered to the plate at intervals round the ridge (supposing the case is a complete upper); and from this point the case is proceeded with as a vulcanite one. The best method of construction is, after the plate is properly fitted mount the teeth upon it, dressing the wax to exact dimensions. The best position for the "catches" may now be readily observed and marked, by piercing through the *wax* with a broach or otherwise. If the *plate* be now slightly heated, the wax and teeth will come away "in block." The catches are next soldered; three or four are sufficient for a small

upper. They are made of stout plate—or flattened pin-wire may be used—between a quarter and a half-inch long, and, if plate, fully an eighth broad. They should be bent, so that, when soldered to the plate at their middle, both ends will remain free to hold in the vulcanite. To retain them in position while soldering they may be lashed to the plate with binding-wire; the case should be thoroughly heated up before approaching the catch with the flame. These having been soldered, the plate is cleaned in the acid, and afterwards the surface to be covered by vulcanite should be scraped (it is sometimes also "barbed" by a cornered graver to a "rasp" surface). The wax under the teeth should now be excavated where it comes in contact with the catches; the plate may then be slightly heated, and the wax with the teeth, placed in position, the hot knife being used to close the edges. The wax in some of these cases is made to cover the whole lingual surface of the plate, but generally only sufficient is used along the ridge to give a setting to the teeth. In the latter case, when casting into the lower part of the flask, the plaster should be made to quite cover the exposed plate.

For the second method—that in which the gold is placed upon the lingual surface of the vulcanite—proceed exactly as for vulcanite, as far as preparing the case for the flask; when this has been accomplished, the case is cemented to the model, and a sand impression is taken of the lingual surface of the wax plate. A zinc and lead having been procured, the gold plate is struck over the part desired. Upon the under surface of the plate, when it has

been properly fitted and dressed, "catches" must be soldered as described for the former case, though generally of rather smaller size. In order afterwards to secure the strengthener, so that it shall not become displaced in the closing of the flask after packing with vulcanite, a temporary fastening should be soldered to its lingual surface. Wire, somewhat thinner than pin-wire, or a narrow cutting of strong plate, may be used for this purpose. It should be rather more than a quarter-inch long, and bent to a sharp angle close to one end; this short end is clamped to the centre of the plate and soldered, *slightly* (so that it may the more easily be removed when the case has been vulcanized). The long end of the hold which should thus stand at a right angle to the plate should be straight, so that afterwards, when closing and opening the flask immediately after packing, the strengthener may be removed from the plaster and replaced again perfectly in position. Sometimes it may be advisable to solder two temporary fastenings to the lingual surface; in that case they should be soldered so as to lie parallel with each other, with the view as before of withdrawing it readily should that be found desirable.

Before placing the strengthener upon the wax, excavate the latter freely, to admit the catches of the former; by this means it may be placed more accurately in position than if it were simply heated and sunk into the wax. From this point the procedure is of course exactly as for vulcanite. The flasking having been performed according to the *second* method, on opening the flask the plate will

come away with the plaster of the upper part, while the teeth and model remain bound together in the lower. The wax having been cleared and the case "packed" in the usual manner, it will frequently be found advisable, as has already been observed, to remove the plate from the plaster, in order that the flask may be closed in the press and reopened for inspection; before the final closing of course the strengthener is replaced, then perfect closure is effected, the clamp put on, and the case vulcanized.

The third way in which gold or metal may be combined with vulcanite is by imbedding it completely in the substance of the latter. A wire, for example, or narrow plate, may be bent to suitable shape and placed in the centre of the case while packing. Or again, flat teeth are sometimes soldered to a plate which has been struck, not to the gum, but to a thin layer of wax covering the gum; so that in packing the vulcanite may be made to cover the under as well as the upper surface of the plate; the latter should have had a sufficient number of holes drilled in it, and so disposed, that they shall give a good hold to the vulcanite without weakening the gold.

The first method of combination—a simple gold plate struck in the usual manner, with the teeth vulcanized upon it—is a most satisfactory one, and is very generally adopted by dentists. A case made on this principle possesses all the advantages of the simple gold plate, and it may be constructed and finished in much less time.

Plates or wires combined with the vulcanite according to the second and third plans are called

strengtheners. So far as they are meant to give strength to the vulcanite, however, they are altogether unnecessary, unless in a few exceptional cases seldom met with. Some years ago, in consequence of a considerable number of fractured cases occurring, we adopted this system—more especially on the second plan—very extensively, giving nearly every vulcanite case a plate of gold on its lingual surface. The cause of the fractures was, however, afterwards traced to over-firing, and when that error was corrected the vulcanite was found to be elastic and strong, and the strengtheners were dispensed with, as being unnecessary.*

It has been already observed that one of the properties of vulcanite is, that it will permit of being bent to an angle of at least 45°, and return to its original form. But two essential points must be observed in order that this characteristic property of the material may be retained: first, the rubber after packing must be consolidated in a complete manner (for this the press or vice is required); and second, the rubber must be carefully fired at the temperature ascertained to be most suitable for it. If either of these conditions be neglected, then the vulcanite will be weak and untrustworthy.

The wires and narrow plates imbedded in the rubber, as in lower or upper "bridges," are particularly objectionable; as, besides being unneces-

* It is well known that vulcanite does not cling to a silver or even a dental alloy surface, and strengtheners made of these metals are found after vulcanizing to be more or less loose in the vulcanite; if such strengtheners receive a gold surface by the battery process, the vulcanite will then hold, of course, as it does upon a gold plate.

sary, they prevent that elasticity of the piece by which alone frequently these cases can be *inserted* and *retained* in the mouth satisfactorily.

The second method, however—the gold plate on the lingual surface of the vulcanite—is often adopted, simply in order to give a better appearance to the work.

The exceptional cases referred to in which it is necessary to give some kind of plate strengthener to the vulcanite are those which ought to be made altogether in gold, but which for some reason *must* be made in vulcanite. These are generally partial pieces with several artificial teeth standing in an isolated position, and with a close bite. The plate used in these circumstances should be, if possible, combined according to the second plan—placed over the lingual surface of the wax—and the gold should be continued over the ridge into the spaces occupied by the artificial teeth in the form of a tongue, and reaching to within a short distance of the platinum pins. It is at this part of the ridge, which is generally high, that there is the chief danger of the rubber being "worn" by the tongue and opposing teeth, and ultimately giving way.

Although "soldered teeth" in a vulcanite case is a combination most of all to be avoided—on account of the difficulties generally attending the repairing of such pieces and for other reasons—it may occasionally be found necessary to construct a piece in this manner. In such instances the bite comes almost or quite close to the gum and to the back of the artificial tooth; the strengthening plate must then be struck directly to the model,

and the teeth soldered to it in the usual manner; small catches must of course be also soldered to the upper surface of the plate in the position where most vulcanite can be employed to cover them, and the same surface may be "barbed;" sometimes only one or two teeth of a case require to be treated in this manner. Again, a strip of plate may be used, one end being bent up and forming the back of the artificial tooth, while the remaining and larger part comes over the ridge and may be imbedded in the vulcanite.

In all those cases where teeth are soldered to a plate, and the latter is *imbedded* in the vulcanite, care must be taken when inserting the piece in the lower chamber of the flask, where the plaster is brought up in front of the teeth, that the plaster does not come over and *enclose* their points, or the motion which the plate is subjected to in packing and closing the flask, being resisted by the fixed tooth, the latter is subjected to a strain which will probably break it. If the plaster is not brought over to the back of the point of the tooth, then the latter will be capable of the very slight movement which is sufficient to prevent its breaking.

As has been said, this style of work is most unsatisfactory, and should only be resorted to under very special circumstances.

CHAPTER X.

PIVOTING TEETH.

"THIS method of securing teeth was, until recently, on account of its simplicity, more extensively practised than any other, and, under favourable circumstances, is unquestionably one of the best that can be adopted. If the roots on which they are placed be sound and healthy, and the back part of the jaws supplied with natural teeth, so as to prevent those with which the artificial antagonize from striking them too directly, they will subserve the purposes of the natural organs more perfectly than any other description of dental substitute, and can be made to present an appearance so natural as to escape detection upon the closest scrutiny." *

Mr. Tomes, in his "System of Dental Surgery," says "that the root destined to receive the pivot, together with the surrounding parts, should be perfectly free from disease. Hence the most satisfactory cases are those in which the nerve in the root has retained its vitality; and as the operation

* Harris's "Principles and Practice."

of pivoting is only generally applicable to the incisors and canines of the upper jaw, the nerve should be extirpated by a nerve extractor rather than by the use of an escharotic.

"The operation then is commenced by removing, by means of the saw, the cutting forceps, or the file, down to the level of the gum, such portions of the crown of the faulty tooth as may still be standing. The choice of instruments will depend upon the condition of the part to be removed. When the neck of the tooth is strong and sound, the saw may be entered upon each side to within a short distance of the pulp, and the operation of excision be completed with the cutting forceps. If the latter instrument only were employed, a risk of shaking the root in its socket, or of splintering it within the gum, would be incurred. If, on the other hand, the neck of the tooth has been encroached upon by caries, or the crown has been broken off near the margin of the gum, the cutting forceps and the file only will be required, or, perhaps, only the latter instrument.

"The exposed surface of the root must now be cut down with a half-round file to the level of the gum, and even a little below its free edge. The next step in the operation will consist in reducing the pulp cavity to a perfectly cylindrical canal, which should be extended to within a short distance of the extremity of the root. To effect this purpose a five-sided broach may be used, but I have found a half-round drill preferable. From time to time the depth of the hole must be gauged, otherwise the drill may be carried to too great a

depth. I have known the broach passed through the root of a tooth into the alveolus."

The root having been prepared, the artificial tooth must be carefully selected, so as to match the natural ones in colour and shape. The kind of tooth, whether tube or flat, must depend on the position of the cavity in the root, and also upon the "bite." The ordinary tube tooth may be employed if the tubes in tooth and root are continuous, that is if, when the former is fitted and in position, a wire can be passed through both. Besides this the "bite" must be such as to allow a sufficient thickness or strength of tooth to be retained behind; what is known as a close bite would require so much of the back to be ground, to "let up" the bite, that no strength would be preserved in the tooth. Though the cavity in the root and the tube in the tooth may not be exactly in the same line, still, if they agree at the point of union, a tube tooth and gold pivot may be used, as the latter may be bent to an angle which will give the tooth its proper direction. Should the cavity in the root be out of position or the bite be unfavourable, then a flat tooth must be employed.

There may be some cases in which it is advisable to fit the artificial tooth directly to the root in the mouth, but as a rule a small model is taken in the following manner. A piece of copper wire is first inserted in the root; the wire should be about a quarter of an inch longer than the drilled cavity of the latter, and should fit it easily but not loosely. Wax or composition is then placed in a small impression-tray and an impression taken.

Or the tray may be dispensed with, the material being pressed into the space and withdrawn between the finger and thumb. The copper wire comes away with the impression, and is cast with it. When the plaster model is obtained the copper wire is withdrawn, and the hole thus left in the plaster exactly represents the cavity in the natural root.

Tube teeth are most readily mounted upon pivots. The tooth having been fitted to the model to the correct length and position, is then fastened with sulphur upon a piece of gold pin wire which is long enough to form the pivot also, and which has been bent, if necessary, to give the artificial tooth its proper direction. Fig. 78 shows in section a tube tooth mounted on a pivot. Before fastening the wire into the tooth it should be scraped, and barbed or roughened with a sharp graver. The pivot, before inserting the case into the mouth, is generally covered with a thread of floss-silk, touched with mastic varnish.

Fig. 78. Pivot Tooth (tube), in section.

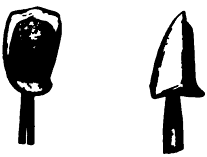
Where a flat tooth is used it is necessary in the first place to fit a small piece of gold plate to the root just sufficient to cover it. This is in most cases easily effected by the pliers, but sometimes a single metal model and counter is used. The position of the root cavity must next be marked on the small plate, which is then drilled or punched for the reception of the gold pivot. To obtain the mark on the plate, insert in the cavity of the root a piece of copper wire, the end of which, filed to a point, appears *just* above the level of the cavity.

This point is tipped with colour, and the plate being brought steadily down into position upon it, the required mark is obtained. The *direction* of the cavity in the root must be noted, and the gold pivot soldered into the plate in that direction. From this stage the method of working is the same as that already described in connection with flat teeth upon gold plates.

Pivot teeth are as a rule inserted in one or other of the ways above described. There are other methods employed, however. Wood pivots are used instead of, or in combination with, the gold ones; or a gold or platinum tube may be fastened into the cavity of the root for the reception of the gold pivot, the latter in such cases being formed of "split" gold pin wire. For those entirely made of wood special teeth are manufactured, having tubes of large diameter. The pivot wood having been consolidated by drawing it through a suitable hole in the draw-plate, one end is carefully inserted into the artificial tooth, and the other is reduced to the size required for the pivot. In using wood for this purpose, the pressure employed either for inserting it into the artificial tooth or the root must be less than that used for gold pivots, as the wood expands after its insertion into the root; if, therefore, it was forced too tightly into the respective tubes there would be some risk of the natural root being split, and also of the artificial tooth giving way. Again, a gold wire having had a thread formed upon it may be screwed into a suitable piece of wood; the latter is then reduced so as to fit into the respective cavities.

The most perfect method of pivoting, however, is first of all to fix a gold or platinum tube in the cavity of the root; a tooth is then mounted upon a "split" pivot, which by its own spring is retained in position. This plan is seldom adopted on account of the time it demands, otherwise it gives most satisfactory results. Richardson says in regard to it, "The best and most approved method of attaching the crown to the root consists in adjusting a metal pivot to a gold tube attached to the root in such a manner that the substitute may be readily applied and removed by the patient. The tube which lines the enlarged canal in the root is constructed and applied in the following manner. A thin strip of gold plate five or six inches in length is first bent round a polished cylindrical steel wire the size of the intended pivot; these are both drawn together through a draw-plate until the gold tube is accurately conformed to the steel rod. The wire is then withdrawn and the joint or seam in the tube soldered; before doing which, however, the joint should be coated on the inside with a mixture of whiting to prevent the solder from flowing in upon the inner walls of the tube. A fine thread is then cut with a screw-plate on the tube, and having introduced into the latter a piece of the steel wire on which the tube was formed, the tube is seized with pliers or a small hand-vice and screwed gently and carefully into the fang. The steel wire is then withdrawn, and the protruding part of the tube removed with a file or cut off with a fine saw." Instead of screwing the tube into the root it may be simply

fitted in and fixed with adhesive gold or amalgam packed round its lower end. To do this, after the cavity in the root has been enlarged to the size required to admit the tube, a burr drill is used to make a sufficiently deep countersink in the cavity; the tube is then introduced and the countersink is packed with adhesive gold. Platinum tubes are sold by the manufacturers for this work, and with them amalgam may be used to pack into the excavation and fix the tube. To make a satisfactory split pin we have found it better to *file* the gold wire half round instead of drawing it, then



Figs. 79 and 80. Pivot Tooth (flat) back and side view.

the two halves receive a thin coating of whiting on their flat surfaces, excepting about an eighth of an inch at one end, which must be left perfectly clean. The halves are then closed accurately together, and the small part at the end—untouched by the whiting—is soldered; this latter part is of course inserted and soldered into the plate, which—for flat teeth—is fitted over the root. Thus, when the case is finished, the split pin may be slightly separated, and its spring will retain the substitute perfectly in position. Fig. 79 shows a flat tooth mounted with a split pivot; Fig. 80 gives a side view of the same.

CHAPTER XI.

REPAIRING.

Gold Plates.—In the case of a plate with flat teeth, to which a tooth is to be added, the most satisfactory method is to select at once a tooth most suitable for the space and fit it to the mouth. The plate is then prepared by filing down any collar or clasp which may encircle the space to be filled, and otherwise making the joint suitable for soldering. The tooth is "backed," and a small piece of wax having been softened and pressed into the vacancy of the plate, it (the tooth) is then fixed in position upon the latter with cement or wax. In order to attach the teeth firmly to the wax and plate, so that slight alterations may be made as to length and direction while the case is in the mouth without loosening them, it is necessary to have the main plate perfectly dry and slightly heated when adding the wax; the plate back of the tooth should also be heated, so that on touching it with wax the latter will be melted and a coating be left on the surface of the back. The tooth is then placed in position, and a hot knife passed down between the parts will effectually secure

them. If these precautions are not taken, some annoyance will be experienced from the teeth dropping from the wax while the case is being tried in the mouth.

When the position of the tooth with respect to circle and bite, &c., is ascertained to be correct, the case is removed from the mouth and at once imbedded in the investient in the usual manner; when the latter is hard and the wax cleared away, the space which is found between the back of the tooth and the main plate must be filled by a small piece of plate closely fitted. In soldering these cases particular care is required, for if the flame be made to solder one joint before the other, the small added plate will probably rise out of position. Thus if the joint made by the main plate with the small one be soldered first, the latter will be drawn up more or less from the back of the tooth, and if the joint made with the tooth back be first soldered, the added plate is then drawn up from the main one. To prevent this the parts must be soldered as far as possible simultaneously; heat one joint just sufficient to "sweat," but not to flow, the solder, then turn the flame upon the other; the sweated solder of the one part fixes it sufficiently to resist the tendency to "rise" while the other is being soldered.

The teeth, instead of being backed at the stage mentioned above, may have the backs put on after the case has been placed in the investient and the wax removed. This plan is practised in all cases by some dentists, but the other is generally preferred.

This method of repairing or adding to plates may be adopted when several teeth are to be added, provided the surface to be covered by the new plate is not so considerable as to render it advisable to fit the latter by striking it between metal models.

Where the addition cannot be made in the above manner, an *impression* of the parts must be taken in either of two ways. Softened wax or composition, in a small lump, is pressed into the space in the plate which is to be supplied with teeth; the plate and wax are then placed in the mouth, and the latter material is pressed up with the finger, to take the form of the gum, the artificial piece being held steadily in position; the patient may close the opposing teeth upon the wax; thus an impression and *bite* is obtained. The case being then removed with the wax attached, a plaster model is made. The second way of taking impressions in such cases is best where large additions are required. Wax or composition having been placed in a tray, an impression is taken with the artificial piece in position in the mouth; the piece comes away with the impression material, when the latter is withdrawn, and a plaster model is cast of the whole. When this has been obtained, the artificial piece will be found occupying the exact position on the model which it did in the mouth.

The model and bite having been cast, the plate is then taken off and prepared so as to make a satisfactory joint along the line where the new one will join with it. After this has been done it

is again placed upon the model and cemented to it, when a sand impression is taken, which need be accurate only over the surface to be covered by the new plate. This must be cut to pattern and struck so as to fit over the required space and slightly overlap the old plate along the border of union. The teeth are then fitted and backed, and the parts having been cemented together the case is imbedded in plaster and sand, and the after stages are the same as in the case already described. Before placing these repairs in the investient a little wax from a hot knife should be run along the line of joint on the under or palate surface of the plate; when this is done the solder is more readily drawn through.

Large additions are sometimes made by means of vulcanite. A small upper, for example, of a few teeth is made up to a complete or almost complete set by making up the required outline with wax upon which the new teeth are set, and the piece is proceeded with as for vulcanite. The plate in these cases must be supplied with suitable catches for holding the vulcanite securely. This method of repairing is extensively practised; but the difficulty of accomplishing future repairs in all instances where soldered teeth are combined with vulcanite, should an accident happen to these teeth, is a great objection to adopting it.

Vulcanite Repairs.—The same method as that just explained for gold repairs is of course equally applicable for these. The vulcanite having been first "scraped" in the neighbourhood of the space to be filled, is then filed into such dovetails as will

give the best hold for the new vulcanite. Soft wax is then added to the part, and the chosen tooth set and fixed upon it. The wax should be somewhat full at the gum border, and the tooth left rather longer than the neighbouring ones, so that when the piece is placed in the mouth it may be moved in the soft wax to the correct position more easily than if it were short and had to be drawn down; the wax by the same pressure takes the form of the gum. Upon removing the case from the mouth, it may be necessary to apply a hot knife to the wax to secure the tooth in the new position; this must be done with care. The piece is then imbedded in the lower part of a two-part flask, the plaster being brought up over the teeth and vulcanite as well, leaving only the labial surface of the wax exposed.

When the flask is opened and the wax removed by the boiling water, the surfaces to be covered by the new rubber should be thoroughly scraped before packing.

Where large additions are to be made to a vulcanite piece, the same methods as regards taking the impression, &c., may be adopted as that explained in connection with gold repairs.

To Reset the Teeth of a Vulcanite Piece.—It is sometimes necessary to take the teeth out of a vulcanite piece and reset them on a new plate and to a new model, while they must occupy the same position exactly with respect to height and projection as before.

In such cases, before removing the teeth from the old piece, cement the latter in position upon the new model, which must be prepared for taking

a bite. The bite, or "circle," as it is called, is made by covering the points and crowns of the teeth over with the plaster, which should also be brought partly over their faces; otherwise it is constructed as an ordinary bite. After this has hardened and been separated, the vulcanite piece must then be thoroughly softened in boiling oil or over the gas-jet when the teeth are extracted, and thoroughly cleansed. The four or six front teeth are next placed accurately in the sockets left by their points in the plaster circle, secured if necessary by a little cement. A wax plate having been made for the model, the circle with the teeth attached is closed upon it, and the teeth are secured at their necks to the wax plate; the circle is then removed and the wax filled in upon the backs of the teeth. The bicuspids and molars are then mounted in the same manner. By this means the original position is exactly reproduced in the new set.

Where it is necessary to imitate minutely the outline of the vulcanite gum of the old piece also, we must, besides the "circle" which has been already obtained, take a cast of the vulcanite gum. Make a "parting" cut or groove on each side of the model, and, having oiled the latter and the vulcanite, cast a shell of plaster round model and vulcanite gum. This outside covering must be made in two parts, the line of division being along the centre line between the front incisors. If it was cast in one part of course it could not be removed.

This outside "circle" of plaster is sometimes cast first, and is brought up in front of the teeth as far

as their tips; the "bite" circle is then cast, forming a cap which covers the crowns only of the teeth. When this plan is adopted the method of setting the teeth is changed. The wax plate having been placed upon the model, the outside circles are then adjusted to the latter; the teeth are then placed in their respective impressions in these circles and secured behind with wax, the "bite circle" being used as the guide for their height. As a general rule these outside circles are not used; the "bite" first described, in which the plaster is made to enclose the points of the teeth, is all that is usually employed; for the outline of the gum the eye is sufficient guide to build the wax to a close resemblance of the original piece.

CHAPTER XII.

CONTINUOUS GUM WORK.

IN this kind of work a platinum plate is struck up in the usual manner. Upon this the teeth are set and fastened behind with cement. The case is then imbedded in the plaster and *asbestos* mixture. When this is hard, and the cement has been removed, the teeth are then "backed," and the joints are soldered with fine gold. The piece, after it has been taken from the investient (the bottom or model part of which should be kept carefully for future use), has its lingual surface including the backs of the teeth covered with a mineral paste; the front of the plate also and necks of the teeth are built up with the paste to imitate the natural gums. The whole is then placed in the muffle of a furnace specially contrived for this purpose, and heated until the material vitrifies. Fig. 81 represents such a furnace in which the ordinary fuel is employed; Fig. 82 is a gas-furnace made by Mr. Fletcher.

The substances used for this work may be obtained from the depôts. The muffle furnace in a variety of forms may also be purchased from the dealers; or a "home-made" one may be easily

constructed. Continuous gum work is not much practised in England; but in America, where the system was matured, it is very popular.

For the following details of this process we are indebted to an article on the subject in Dr.

Fig. 81. Muffle Furnace.

Richardson's work, and also to an article contributed by Dr. Roberts to an American journal.

Metallic Base.—"Whenever the porcelain body is united by direct fusion with the metallic base, the latter should be constructed of platinum, as this is the only metal which will withstand the heat

necessary to vitrify the cements in common use. Platinum, both from its infusible nature and comparative exemption from contraction, is admirably adapted to this process; and did it possess the stiffness and elasticity of ordinary gold plate its suitableness would be still further enhanced. It is not improbable that at no very distant period, as before intimated, porcelain cements sufficiently fusible, and possessing otherwise the necessary requisites, will be compounded, justifying the employment of gold alloyed with platinum as a base. At present, gold or its alloys can only be used in connection with this process in those cases where the teeth are united in sections or entire arches independently of the plate base, being subsequently attached to the latter either by riveting or with the use of solder.

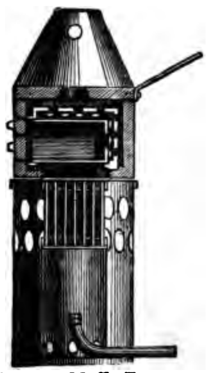


Fig. 82. Muffle Furnace (gas), Fletcher's.

The thickness of plate used will be determined somewhat by the form of the palatal vault and the manner of constructing the metallic base. Ordinarily No. 30 plate may be used; if, however, the arch is shallow and broad, increased thickness should be given to it. On the other hand, if the arch is deep, and marked by prominent rugæ or other sharply defined irregularities of surface, a plate somewhat thinner than that specified may be employed; and if the plate is doubled in the centre, and the space filled in with gum material, plate

No. 32 or 33 will suffice.* In all cases the perfect integrity of the piece requires that the absorption of the ridge shall be complete, otherwise no practicable thickness of a single lamina of platinum will, on account of the soft and pliant condition of this metal, provide perfectly against fracture and deformity in mastication.

It is unnecessary to repeat in this connection what has already been fully described in regard to impressions of the mouth or the manipulations connected with the formation of plaster models and metallic swages, these processes being essentially the same as in the construction of ordinary gold work. Whenever a rim is to be formed to the border of the plate extending from heel to heel of the latter—and this is to be accomplished by swaging—then an abrupt shoulder of plaster must be added to the model along the border where the edge of the plate is desired to be turned up before casting in sand. If it is designed to enamel the entire lingual surface of the plate (a method now commonly practised), the shoulder upon the model should be extended across the heel of the latter from each extremity of the ridge on a line with the posterior border of the hard palate, to form a groove in swaging similar to and continuous with that on the outside of the ridge. The edges thus turned in swaging will flare more than is required; the operation must therefore be completed by carefully turning them over sufficiently with the pliers. In place of swaging the rim, however, it may be formed by fitting and soldering along the border a

* These numbers represent, of course, the American gauge.

narrow plain strip of platinum, extending it as before, if desired, across the posterior edge of the plate. This edge of the plate—that is the lingual edge which crosses the floor of the mouth in an upper case—should always have a narrow strip of the platinum soldered upon it; this leaves a thick edge for the enamel to be dressed against, thus leaving the latter strong and well protected. The outer border of this added rim is of course filed towards the gum. A triangular wire may be used for the above purpose instead of the narrow strip of plate.

In whatever way the rim or socket is formed, it is practically of the first importance that the exact dimensions of the plate required should be ascertained before the groove is formed, as it will be impossible to subsequently diminish the extent of the borders without to some extent impairing the integrity of the finished work. The mouth, therefore, should be carefully examined, and the precise location, extent, and fulness of the muscles and integuments along the external borders of the ridge above and below, the glands underneath the tongue, and the extreme boundaries of the hard palate carefully noted and accurately traced upon the plaster model to serve as a guide in determining the dimensions of the paste.

Zinc and lead are particularly destructive to platinum where the two are heated together, therefore after swaging the plate should be carefully pickled in nitric acid.

The ordinary flat or vulcanite teeth may be used for this work, and they are mounted and fastened

with the cement behind, as already described in connection with other work. They should not, however, be fitted accurately to the plate, but should be set upon a layer of wax; the spaces thus left between the bases of the teeth and the plate will afford a hold to the enamel afterwards to be used.

The case is then imbedded in a mixture of equal parts of plaster and asbestos as for ordinary soldering. When this hardens the cement is cleared from the backs of the teeth, which are then ready to receive their linings, or backs, and attachments to the plate.

Lining the Teeth.—The method of attaching the teeth to the plate by means of stays or linings will depend somewhat upon the construction of the teeth manufactured expressly for this process. They are formed usually with two or more platinum pins or rivets, but those known as "Roberts's teeth," having but a single long pin, require a different application of the stays from those commonly used. The method of lining the ordinary or double-pinned teeth will be first described. A strip of platinum, equal in width to the tooth to which it is applied and one-half of the spaces next adjoining, is pierced to receive the platinum pins, the end resting upon the plate being split into several sections and bent at a right angle with stay, extending back upon the plate an eighth of an inch. The portions of the lining which extend beyond the sides of the teeth are slit even with the sides of the tooth about half-way down from the top of the stay. The linings are thus separately formed and adjusted

to each tooth, and when applied are fastened by pressing the pins together with pliers, while the lateral strips are doubled upon each other and interlocked, thus uniting them throughout.

In the use of teeth having but one long pin their attachment is effected by fitting a strip of platinum plate underneath the pins, extending continuously from heel to heel of the plate, the lower edge resting upon the latter. It is best first to fit a strip of sheet lead to the curvatures of the teeth and to the surface of the plate, to be used as a pattern in cutting out the platinum band. The strip is sometimes formed in sections, in which case they should be united by interlocking the ends. In order to strengthen the attachment this band may be doubled or wired, or additional strips of platinum or pieces of wire may be placed continuously or at intervals along the points of contact between the band and plate. When adjusted it is fixed in place by bending the pins down over it, the band being previously perforated with numerous small holes through which the gum body passes, binding the several parts more perfectly together.

Soldering.—It should be remembered in manipulating this work that the appropriate and only solder for it is *pure gold*. The teeth lined, small pieces of this metal are applied at all points to be united, each piece as it is applied being touched with borax ground in water. The gold should be applied in sufficient quantities to unite perfectly all the parts, and may be confined within certain limits, when fused, by scoring the surface of the plate with a sharp instrument immediately inside

of the linings, or wherever it is desired to limit the flow of the solder. The piece is now placed in the muffle of the furnace, and the heat raised on it till the gold flows, when it should be immediately withdrawn and placed in a cold muffle to cool gradually, the end of the latter being closed. Or the piece may be removed at a red heat from the furnace and soldered with the blowpipe in the ordinary way. When cold, the external covering of the investient is cut away, leaving that portion uninjured on which the plate rests, to serve as a base for the plate in the process of baking the body. The plate and teeth separated from the plaster, are now immersed in a dilute solution of nitric acid, where they are allowed to remain until all adhering particles of vitrified borax are removed, after which the piece is thoroughly washed. To insure a more perfect adhesion of the body to the plate, it is recommended, after having placed the plate upon the die, to scratch or etch with a sharp-pointed instrument the entire lingual surface of the platinum base. The piece is now ready for the application of the gum body.

Application and Fusion of the Body or Base.— The material for the base or body is mixed with sufficient water to form a paste, the portion first applied being sufficiently thin to admit of being worked perfectly into all the minute crevices or interstices around and underneath the ends of the teeth, and about the platinum linings, and into the contracted fissure or groove formed by the rim. When these interspaces are filled in as perfectly as possible, the redundant water may be taken up

partially by applying to the paste, wherever practicable, small pieces of tissue or bibulous paper, when the paste, thus partially deprived of its water, should again be worked in and impacted as perfectly as possible with small, sharp, straight, and curve-pointed knives or spatulas. Before filling in with the body into the more open spaces between the roots of the teeth, the former may be partially filled up with fragments of the crowns of broken teeth, around which and the roots of the teeth the porcelain paste, now used much drier and thicker than at first, is packed as hard and solid as possible. Small portions are thus added from time to time until the required fulness of the gum between and external to the teeth is obtained, drying out occasionally with a clean napkin or tissue paper, and at the same time pressing and patting it with the instrument to drive out entangled portions of air. The paste is likewise applied to the platinum stays, covering them to the depth of from a half to three-fourths of a line, making it fuller as it approaches the plate, and rounding it off at this point with a retreating edge extending back an eighth of an inch or more. If it is designed to enamel the lingual surface of the plate, the gum body should be applied the thickness of a dime to the entire surface continuously with that upon the backings, filling into the groove around the chamber with a uniform surface. The porcelain paste should be carved neatly at the necks of the teeth, and on the exterior or labial surface a shallow concavity or furrow may be formed by cutting out a small portion of the body from between the roots of the

teeth, thus forming a ridge over the fangs of the teeth in imitation of the natural gum. The effect of this carving will be still further enhanced after the application of the gum enamel, which being applied evenly over the surface, a greater depth of gum colour will be imparted to those parts over the furrows, while the intermediate portions over the roots will appear somewhat blanched, or of a lighter gum colour, as in the natural gum.

After the application of the base in the manner described, the crowns of the teeth should be well cleansed with a camel-hair brush of all adhering particles of paste, and the uncovered portions of the plate with a moistened napkin, when the piece should be readjusted to the "plaster and asbestos" base previously used in soldering, placed upon a fireclay slab or slide and introduced first into the upper muffle of the furnace, where it may be allowed to remain exposed to a gradually increasing heat until it is thoroughly dried; when it acquires a red heat it may be transferred to the lower muffle, and the heat urged until partial vitrification of the body takes place, and which may be determined by a slight glossiness of the surface. When baked or biscuited in this manner it may be removed and reintroduced into a cold muffle as when soldering. When the piece is quite cool it must be placed upon a metallic die to detect any alteration in fit, and to restore it to its former shape, which may be done by pressing it down with the hand or by tapping the molar teeth with a wooden or a horn hammer and pressing the plate at the same time firmly down to the die. Should cracks be produced

in the body it is no matter, as these will be filled up in the second baking.

Second Coating.— The paste for the second coating is made the same as that for the first. It is carefully laid upon all the parts that require to be built out, and is introduced into all the crevices into which it is made to settle by lightly tapping the piece. With the little spatula the surface is nicely carved and shaped around the roots of the teeth. A little ridge is raised with a camel-hair pencil from the line between the two central incisors, running back along the palatal surface to the middle of the posterior edge of the plate, and this ridge is next halved by a central line made along its whole length by the brush or the edge of the spatula. On each side of the ridge little prominences are to be raised to imitate the rugæ of the mouth. The second baking must then be conducted like the first (only a little harder), and the cooling also, when the piece should be again placed upon the metallic die in case of alteration in fit. It is now ready for colouring.

Enamelling or Gumming. — The gum, being mixed as was the body, should be laid on evenly and in proportions only to be learned by experience; and in the selection of shades of colour you must be guided by your own taste. I should recommend, however, the use of a very thin coating at first, afterwards a deeper shade can be given by a second coating. If the teeth have been etched in soldering, a little coating of "etching enamel" of the consistency of cream should be laid upon them with a camel-hair pencil. The plate being then cleansed

and replaced upon its investient model is ready for the furnace, but more care is now required not to expose too suddenly to a high degree of heat. If pushed too fast into the muffle pieces are likely to scale off, leaving defective spots such that it would be necessary to remove the work, cool it down, and repair with more gum. When well heated in the upper muffle the piece may be removed to the lower one and exposed to a full white heat for from ten to twenty minutes, or until the gum has thoroughly flowed and shines like melted glass. It is now to be removed, cooled down as before in a cold muffle. When at blood heat take it out, and place it in water of about the same temperature. Avoid touching it with the fingers. This is an effectual method of preventing the checking or grazing of the gum, which frequently occurred in the old way of annealing when the piece was cooled and taken in the hands.

The next and last operation is the polishing. I remove from the plate any little particles of gum or body, and rub it thoroughly with fine sandpaper, then with a fine stick and pumice-stone, and lastly with a steel burnisher or bloodstone with a little soap-suds."

Partial Sets with Continuous Gum.*—"Partial cases may be made with continuous gum; but the work is so various in its nature that the dentist must necessarily depend much upon his own judgment. Difficult cases will constantly present themselves that will require the exercise of much study and

* Dr. Roberts.

ingenuity, and in which the general instructions which can be given in words may be of little service. The first attempt of this kind in my own experience was in replacing two central incisors. Taking two continuous gum teeth, I placed upon them a platinum lining, slitting this down along the edge of the one tooth nearly through the piece, and up the edge of the other tooth by a parallel cut, leaving the two parts joined together by a narrow slit. This allowed sufficient motion between the teeth, so that they could be adjusted as desired. I then placed a bit of tissue paper upon the plaster model covering the spot to be occupied by the teeth and gums to prevent the adhesion of the body to the plaster, and holding the two incisors in their places I worked the body into all the depressions of the gum and around the roots of the teeth. I then removed the whole from the model and placed the piece in a paste of pulverised silex, or plaster and asbestos, and baked as described for full sets. The little slip of platinum kept the two teeth in position. The work shrunk somewhat, but this was remedied by again placing the piece upon the mould with the intervention of tissue paper covered by a thin coating of body. Into this I pressed the piece until it occupied its true place, then filled in again with more body all the crevices around the roots of the teeth, and rebaked.

After enamelling, if the work has been carefully and skilfully done upon this plan, it will be as fine a piece in appearance and fit as can be made. It may then be soldered to a gold plate, and the

little strip of platinum between the teeth be cut out. With the body and gum formerly in use many difficulties were often encountered from discolouration of the gum, or from injuries incurred in soldering. But with Roberts's material these are easily avoided, and the piece can be treated the same as a block or single gum teeth. In partial sets on entire plates of platinum I have sometimes found trouble from the enamel giving way upon the small narrow points that connect the teeth with the plate by the shock occasioned in biting. I have consequently left these points uncovered, and used two or three thicknesses of platinum to give greater strength. But where this is likely to occur, gold plates would be preferable if nicely adapted with single gum teeth or blocks of continuous gum, as the case might require. I have also applied continuous gum in cases where the natural teeth, from one to five in number, were left in the mouth, by making the plate as in full sets, cutting out around the natural ones, and raising a small bead, or placing a light wire round about one-eighth of an inch or more from the teeth against which the gum or body is to be finished. The points around the teeth are to be left free, in order to be burnished down in case of imperfections caused by the difficulty of obtaining exact impressions in these places. In such cases I have sometimes formed a strong standard of several thicknesses of platinum fitting closely against one or more natural teeth, leaving a loophole through which to run a gold clasp for afterwards securing the artificial set.

I have also secured the gold to the standard by rivets of platinum, and sometimes by two or three gold screws, not providing in these cases the loophole. These methods are to be preferred to using solder for fastening, for, in case of repair, the clasps are easily removed without leaving any foreign substance; but in case of soldering, however carefully they may be removed, there will remain some alloy, which in the baking heat to which the piece is to be exposed will be incorporated with the platinum. Even so small an amount of silver as may be in gold coin used for solder will communicate a yellowish tinge to the gum, spoiling the whole work.

Another source of mischief may properly be noticed in this place. In baking, especially with a new furnace or with muffles lately renewed, either at the first or second heat, or it may be in enamelling, the piece is sometimes changed in its texture and colour, as is supposed by the gases present, and the phenomenon is called gassing the piece. The body becomes porous like honeycomb, and of a bluish colour. When this occurs, there is no remedy but to place it upon the metallic die, remove the whole of the injured part, and replace it with a new coating of body and gum. The teeth are seldom, if ever, thus affected. As a precaution, the muffles should be well ventilated with holes for the passage of the heated air and gases.

Repairing.—In case of a single tooth being broken a new one is readily inserted by entirely removing the crown of the injured one, and grinding out a niche in the gum at its base nearly one-

fourth of an inch deep to receive the new tooth; then fill up the niche with body, and press the tooth you wish to insert down to its proper position; trim the surplus body about the neck of the tooth as in full sets, absorb the moisture with a napkin, and apply the gum to the body and wherever required. Stay the tooth with a little plaster and asbestos placed upon its point and reaching over, so as to include the adjoining tooth on each side. A better method, however, is to place the teeth downward, imbedding their points in a paste of pulverized silex laid upon a slide, and then subject the piece to the heat required for enamelling. One baking will generally suffice to complete this operation. But if a piece has been more seriously injured, say by loss of a central canine tooth, with a point broken out from the edge of the gum, and the plate is bent so as to have lost its fit, and the gum shrunken away at any point, we adopt a thorough method of repair. We first take an impression of the mouth and make a plaster model; upon this we place the plate, and over the point where the gum is shrunken we chip off the body and gum, and with a burnisher work the plate down, wherever required, to exactly fit the model. We then make a niche for each tooth to be inserted, apply the body and gum, stay the teeth, and bake the piece as above described. If it has been thoroughly packed two bakings will be sufficient, but sometimes three will be required. The only rule is to repeat the operation till the object is accomplished, taking care always not to overheat the piece. In case of the piece being long worn, it is well, before

doing anything to it, to subject it to a moderate degree of heat, sufficient to burn off any impurities it may have collected in the mouth.

Another set may be presented for repair literally broken to pieces; but the plate remaining a perfect fit, and some of the teeth being undisturbed, we wish to avail ourselves of these. We therefore make a dam of putty around the edge of the plate, and run in fusible metal to form a cast, which shall serve as a support for the plate. Not to endanger cracking the teeth by the heat, the piece may be placed in a dish containing a little water, and after the metal is poured and begins to harden more water may be added, so as to cover the whole mass. But this is hardly necessary if the alloy be run nearly at its cooling temperature.

The piece being now supported upon the cast, and held firmly with one hand, a small chisel made from an excavator may be applied with the other to the old material which it is desirable to remove, and an assistant gently tapping this with a hammer, the body is quickly chipped off between the teeth, and wherever the chisel is directed without injury to other parts, or without misshaping the plate. The teeth may now be inserted and soldered to the plate, with the old or new linings if required, and the new body and gum may then be applied."

CHAPTER XIII.

CELLULOID.

THIS substance was introduced about six years ago as a base for artificial teeth; but it is not at the present time employed to any great extent by dentists for this purpose. The advantages which the material possesses over vulcanite, which it was designed to supersede, are superior colour, greater strength, and a saving of the time required with rubber for the vulcanizing process. These advantages are counterbalanced by the tendency which celluloid plates have to "warp" after they have been finished, and worn some time in the mouth; besides this, the material is not so readily and successfully moulded in every case as vulcanite is. These are very serious defects, and until they can be got rid of there is little prospect of celluloid being generally employed as a base for artificial teeth. It is right to state, however, that though this is the general opinion, there are some who deny that these evils are met with when proper care is exercised in manipulating with this material.

The case is prepared and flasked for celluloid

exactly as for vulcanite; it is of special importance that the plaster should be mixed "thick," so that the parts will withstand the subsequent pressure in closing, which is somewhat more trying than with vulcanite.

When the flask has been opened and the wax perfectly cleared from the mould, a celluloid plate, or "blank," of suitable size, chosen from the various patterns supplied by the manufacturer, is placed in the mould. The flask is then closed and put into an iron vessel or "tank" containing oil, which must be heated to at least 300°. When the heat has rendered the celluloid sufficiently soft, the screw attached to the tank is turned gently down upon the flask. The closing is completed gradually, as the material becomes so soft that the operation may be accomplished with the least possible amount of pressure. The heat is continued for a short time so as to drive off the camphor; the whole must then be allowed to cool thoroughly, when the flask may be unscrewed, opened, and the case taken out and finished.

The following remarks on the derivation, manufacture, and management of celluloid are made by Dr. Finlay Hunt, in a paper read before the American Dental Convention, Long Branch, (August 12th, 1875). "Celluloid, as its name (most judiciously chosen) implies, is a form or condition of cellulose or celluline. These terms are used in the same sense by different writers on chemistry, and, so used, designate that solid, insoluble substance which is found in greater or less proportion, in connection with lignin and with albuminous and

other matter throughout the vegetable kingdom, and forms the walls of the cells of woods and vegetables.

For the purposes of our profession those fibrous vegetables have been taken which contain the greatest proportion of cellulose. Cotton was used at first, but hemp was found to be better, and is now alone used.

The precise process used by the Celluloid Manufacturing Company to convert hemp into celluloid is not known to the present writer, but it will be sufficient at this time to give the general treatment and properties of substances applied in effecting this conversion.

The first step to be taken is to separate the cellulose from its associated substances as found in nature. This is an operation of more or less trouble, as the cellulose is more or less associated with other substances. In the case of cotton it is very simple, as that fibre is composed almost entirely of cellulose of a certain quality. With hemp it is less simple; but with it the process is substantially the same as is required for its conversion into pulp for the manufacture of paper. The cellulose having been segregated from its associated substances is subjected to treatment with nitric acid, by which it is converted into nitro-cellulose. Great care is required in this process to produce the proper and best results, as there are three grades or chemical combinations of nitrogen (or its peroxide) with cellulose, viz. mononitro-cellulose, dinitro-cellulose, and trinitro-cellulose. The first and third of these are in-

soluble in ether and alcohol, and the latter possesses the property of being highly explosive. The second is called by some chemists pyroxyline. It is soluble in ether, or ether and alcohol, and in that condition of solution is known as collodion. It may be remarked here that the terms pyroxyline, collodion, and xyloidine have not yet received the strict chemical definition that is required by pure or exact science.

The dinitro-cellulose or pyroxyline is the chemical compound that is used for the production of celluloid by the addition to it of gum camphor, both being in a finely divided state, and first mixed mechanically. Thus mixed they are subjected to heat and pressure, when a chemical combination seems to take place, resulting in a homogeneous mass. This process is, I believe, called technically by the manufacturers "conversion."

It is well here to speak of the nature of camphor and its action in this and subsequent manipulations. In the combination above spoken of the camphor has the peculiar property of softening the pyroxyline and rendering it plastic. At ordinary temperature, however, this property is almost entirely dormant; the application of heat is necessary to excite it to activity. It is, therefore, in a state of gum, a softener of pyroxyline, and not a solvent as has been incorrectly stated by many, the writer of this included. But gum camphor is volatile, evaporating slowly at ordinary and more rapidly at higher temperatures. Therefore camphor, when exposed to the air, or in contact with or enclosed by previous substances, is constantly

evaporating more or less rapidly, according to the temperature. This evaporation of camphor proceeds even in its most intimate combination with pyroxyline, and, by the continued application of heat, can be so effectually expelled that no appreciable quantity remains, and the celluloid is thus separated into its former constituents, pyroxyline and camphor. It is not, however, either necessary or advisable to proceed so far in the final preparation of dental plates. It is not necessary, because a certain small proportion of camphor left in the plate is not injurious; and it is not advisable, because there is a risk of rendering the material brittle in the effort to expel all the camphor. Pyroxyline possesses the property of elasticity to a considerable degree, but very little of plasticity. Hence, if it is changed by pressure from one shape to another, it has, on the removal of the pressure, a tendency, from its elastic nature, to creep back to its former shape. Its combination with camphor takes away from it the property of elasticity, and in turn gives it that of plasticity in proportion to the quantity of camphor added. As stated above, the camphor can in turn be driven off by evaporation, thereby exchanging plasticity for elasticity. It is absolutely necessary to do this after the plate is moulded and before removing the pressure, and it is called "seasoning" on account of its analogy to the process of seasoning wood by driving off the natural juices.

This material, celluloid, almost devoid of elasticity, can be rendered sufficiently plastic by heat to be moulded by pressure into any form or shape

we may desire, and while under pressure it can be rendered sufficiently elastic to prevent any subsequent change of shape under ordinary circumstances of use.

From what has been said, its behaviour under manipulation, up to the time that the moulding has been completed, may be readily inferred. One important feature—and it should be borne in mind at all times—is that, though quite strong and tough, it has a delicate texture, a disposition, if we may use that term, that requires gentle treatment and coaxing rather than rude force.

We come now to the processes, means, and appliances used for bringing it (celluloid) into the forms and conditions required for our purposes. It comes into our hands in the form of blanks, for full and partial plates. The variety of the shapes and configurations of these blanks is necessarily limited, for it would be impossible to make blanks that would meet all cases presented; therefore they are given to us in such general form that we can prepare them by cutting, if necessary, to suit each case.

Should a case require a greater amount of celluloid than is to be found in a blank, the latter can be pieced out, using a piece or pieces of the same colour. The surfaces intended to come in contact should be painted freely with a solution of celluloid in spirits of camphor. When properly done the union of the surfaces is perfect. The same plan can be used for repairs. As it is necessary to heat these blanks to render them sufficiently plastic for moulding, the processes used

for heating command the first attention. These may be enumerated as follows: oil, hot water, steam, glycerine, and dry heat processes. All these processes have for their common object the application of heat to the celluloid. They only differ in the mode of such application and the degree of results produced. The oil, steam, hot water, and glycerine were intended as baths for the celluloid, to avoid the danger of combustion or explosion of so inflammable a substance as nitro-cellulose of any grade was supposed to be. Afterwards the dry heat process was introduced, and shown to be as free from danger of explosion or combustion, if properly conducted, as any of the others, with the exception of hot water, and perhaps of steam.

Without entering into the particular merits of each of these processes, their general efficiency will be noticed with reference to special ends to be attained or conditions secured in a dental plate or other appliance made of celluloid. These conditions are—that the plate or appliance must fit the mouth, must be free from liability to change of shape, and must possess the best degree of strength, elasticity, and hardness, of which the material is susceptible. The first of these conditions can be secured by any of the named processes, except that of hot water—the possible temperature of this in an open vessel being limited to 212°, while the others can be brought to 400° to 600°. The other two conditions are inseparable in celluloid, and can only be secured by the evaporation of the camphor, which has performed its duty of rendering the material plastic.

It is very evident that this evaporation will not take place so rapidly or effectually in a bath of oil, hot water, glycerine, or steam, as when heat is applied without their intervention. In the use of any of these processes these combined conditions must be considered as indispensable. The preparation of cases for moulding is so well known that I will only suggest that care be taken to use plaster that will set hard; that the faces of the mould be freely rubbed with powdered soapstone,

Fig. 83. Celluloid Press.

by means of chamois-skin or other soft material (this prevents the base plate and celluloid adhering to the cast), and that the modelling composition prepared for taking impressions makes a most excellent base plate. It can be prepared with warm water, a pane of glass for a bed, and a bottle for a roller.

Having the flask all prepared, the operation of moulding is to be carried on, keeping in view three essential points: 1st, to complete the moulding

before too much camphor is driven off; 2nd, while doing this, to shape and point the celluloid while hot and soft, so that it will go wherever desired; 3rd, after the moulding is completed, to keep the plate under pressure and exposed to heat till its plasticity is exchanged for a sufficient degree of elasticity. This being done it is allowed to cool thoroughly before removing from the flask. It is then ready for finishing." *

The figure represents the iron vessel or tank which contains the oil, and in which the flask is placed, and afterwards closed by means of the screw.

* "B. J. of Dent. Science," Sept. 1876.

CHAPTER XIV.

ON THE CONSTRUCTION OF OBTURATORS AND ARTIFICIAL PALATES.

THE palatal organs perform an important part in the production of articulate speech; any defects, therefore, in structure, or any departure even from the ordinary type of formation, is accompanied by an irregularity in the character of the produced sounds more or less marked according to the locality and extent of the defects. In cases of congenital fissure mastication and deglutition are not interfered with to any great extent by the abnormal condition of the parts. Practice, which under such conditions commenced at birth, has no doubt in the course of time developed powers in the surrounding parts which in a great measure compensate for those which are wanting. Besides this, the individual never having experienced a better method in respect to the management of the food, may be said to be unconscious of his misfortune. But in the case of those to whom the defect has come in adult life, discomfort and annoyance are experienced in a very high degree. Therefore in these cases it is necessary for *comfort*, in all cases it

is necessary in order to obtain distinct articulate speech, to close these abnormal openings and to restore as far as possible the functions of the lost parts. To accomplish this by providing the patient with an artificial substitute forms a branch of dental art which has long engaged the attention of the dental surgeon.

The earliest appliance made for palatal defect of which we have any distinct record was that made in 1585 by Ambrose Paré, an eminent French physician. It consisted of a metal plate which fitted over the opening, and to the upper surface of which was fixed a pin with screw; by means of this latter arrangement a piece of sponge was held securely to that surface of the plate next the fissure. When the case was placed in position the sponge passed up into the fissure, and upon absorbing moisture it spread out so as to form upon the superior or nasal border of the latter a kind of rivet which retained the appliance in place. The objections to this description of obturator will be readily understood. The repeated insertion and extraction of these swollen pieces of sponge, which was necessary, injured and increased the extent of the defect. Besides this, the condition of sponge under such circumstances quickly became such as to render the case unwearable on account of its odour. This point was referred to by Laforgue about sixty years ago. He says, "They have always the inconvenience of charging themselves copiously with the fluids, of becoming heavy and falling out of place, and of causing an odour insupportable for the patients and for those who approach them."

Even at the present day, however, this method of securing an artificial palate the dentist is induced sometimes to adopt. Fauchard in 1728 describes a very ingenious appliance invented by him for palatal defects. Instead of the sponge Fauchard constructed on the upper surface of the plate an arrangement of wings. While the obturator was being inserted in the mouth, the wings stood upright so as easily to pass through the opening; when the appliance was in place, the wings were brought down to a more or less horizontal level, thus they lay upon the nasal borders of the opening and retained the plate securely to the palate. This appliance and others contrived about that time injured the natural parts with which they were associated in a very serious manner, and in other respects they were so clumsily fitted to the defective organs, that they were generally recognised to be much more hurtful and inconvenient than useful. About twenty-six years ago Mr. Stearns invented a most ingenious and practically successful description of artificial palate. The principle upon which he acted was, that as the soft parts of the palate are subject to muscular action, any appliance made for these parts should be so constructed as to act in concert with all their movements. By this means what may remain of the soft palate communicates to the artificial velum such motion as enables the latter to perform the functions proper to the parts for which it is a substitute. Figs. 84 and 85 give a view of both sides of this instrument; it will be seen that it consists essentially of two wings which in the drawings

are a certain distance apart along the centre line; a third part is provided which covers the central slit, but which does not prevent the wings from closing when the edges of the fissure approach each other, as in the act of swallowing. Within the last few years an improved artificial palate has been introduced by Professor Kingsley. The principle adopted is the same as that worked out by Stearns, but the palate itself, which is made of soft rubber, is much more simple in its construction.

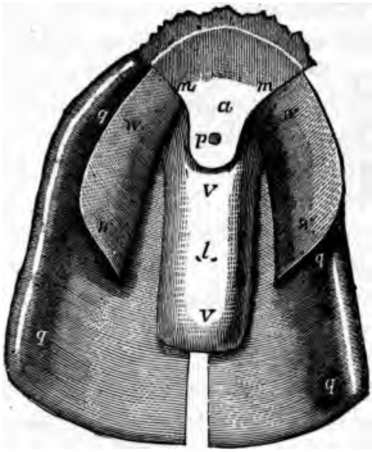


Fig. 84. Artificial Palate (Stearns).

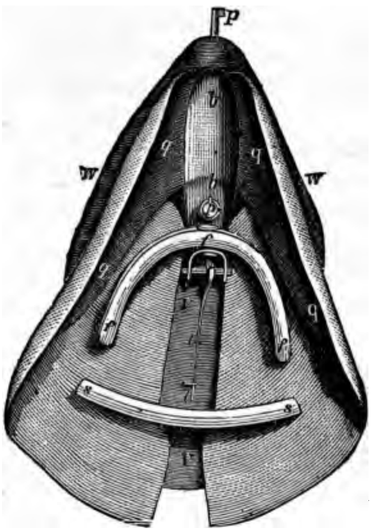


Fig. 85. Artificial Palate (Stearns).

Cases of palatal defect are divided into two classes, according to the immediate causes which may have produced them. First, those

which are the result of arrested development—malformations—are called "congenital;" second, those which are produced by disease or otherwise are called "accidental." A distinguishing feature in the two classes is, that the defect, so far as the palate is concerned, is in congenital cases always in the median line, whereas in accidental cases the defect is generally on one side or other of that line. When the cleft in congenital cases, however, proceeds in an anterior direction, involving the central portion of the jaw and teeth, and ending in fissure of the lip, it then may incline away from the median line in the direction of one or other nasal passage, or it may continue in the median line involving both nasal passages. Accidental defects vary much both as to locality and extent. There may be a simple perforation only of the palate, while in extreme cases, in the opposite direction, the entire soft palate is destroyed, and a considerable portion of the hard palate and jaw with enclosed teeth.

Artificial Appliances.—The two classes of cases being altogether distinct as regards their origin, the artificial appliances made for them ought also to be distinct in their character and structure. Such is the opinion of modern practitioners who have had special experience in this branch of dentistry. Thus cases of accidental fissure may be treated successfully with an obturator,* whereas

* The term "obturator" is applied by Dr. Kingsley to all artificial appliances intended to stop a passage, as all openings in the hard or soft palate which have a *complete boundary*. Appliances made to supply the loss of the posterior soft palate, whether accidental or congenital, he calls artificial palates or "vela."

this kind of instrument falls very far short of what is required in the cases of *congenital* fissure. For these an appliance must be constructed which shall not only restore in appearance the lost parts, but will also restore as far as possible the functions which these parts in a normal condition perform. Nevertheless many experienced practitioners do not adopt this system of treatment, but construct for all cases of palatal defect an instrument of a similar character. This is a simple plate made to cover the opening and to restore as far as possible in superficial appearance only the lost parts; the plate for defects in the hard palate is made of the ordinary vulcanite, for those in the soft palate soft vulcanite is employed. Thus it will be observed that the designs of those who advocate the first method have a much wider reach than is the case with those who adopt the second. In the former case the ideal is perfect restoration, in the latter only partial restoration is considered practicable.

The class of "artificial defects" we may subdivide into three species: first, those cases in which there is a perforation of the hard palate; second, those in which the perforation exists in the soft palate; third, those in which there is partial or complete destruction of the soft palate. This classification might be extended to include one or more other kinds, but the treatment necessary for the three mentioned will indicate that which is proper for all. For the first species—perforations in the hard palate—an obturator is constructed which is rigidly fixed to a more or less extensive plate, fitting to the palàte and teeth. In the second species of perfora-

tion—through the soft palate—an obturator is also constructed, but in order that the muscular movements of which these soft parts are capable may not be interfered with or controlled by the artificial appliance, this obturator must not be rigidly fixed to the main plate, as in the former case, but in such manner that it will readily take part in all the movements of the parts with which it is connected. For the third species of defect, what is called an artificial velum or palate is required.

Construction of Obturators.—Those openings in the hard or soft palate, sometimes almost perfectly circular, at other times very irregular in form, but always completely surrounded by the natural parts, do not generally present any great difficulty in the course of treatment. It is of importance, in the first place, that an accurate impression be obtained of the opening and of the neighbouring parts of the palatal surface, and also of the teeth, if there are any standing. The only material which gives satisfactory results for this work is plaster of Paris; but in using it special care must be observed, for if an excess of plaster be employed, this excess may in the act of taking the impression be pressed through the opening, and form over its superior or nasal border a rivet of plaster, which may render it impossible to withdraw the model without using such an amount of force as may seriously injure the natural parts. The following method may be adopted in order to prevent the possibility of such a difficulty arising. An impression having been taken with "godiva" in the ordinary manner, is cut to a slight depth over its surface; this surface

is then covered with a thin stratum of plaster, and the impression of the parts again obtained. The small amount of plaster used in this method prevents any such accident happening as that above referred to. Or again, take a wax impression, and make from it a plaster model; upon this form a gutta-percha tray, imbedding in it a piece of wire bent into suitable shape for handle. Into this gutta-percha tray plaster is placed in a thin layer over its surface, and the impression is then obtained without risk. Before covering the surface either of the "godiva" or of the gutta-percha, such portion of the material as may have been pressed into the opening must be removed, and also around the defective part the surface of the material should be reduced slightly, just sufficient to insure that only the plaster will be pressed against these parts when the second impression is being taken. A plaster model having been made from the latter, it is next necessary to form upon the model a pattern in gutta-percha, which will exactly represent the obturator as it is intended to be. The material of which these substitutes are made is now almost invariably vulcanite, and the method of procedure to be adopted in constructing them differs in no very material respect from that already explained in connection with the ordinary artificial work. It must be remembered, however, that as the most perfect obturator would be that one which *exactly* represented the lost parts, it is necessary in all these cases to construct the work with great delicacy, so that the appliance will as nearly represent the normal outline of the parts as the circumstances

will allow. Thus it will be possible in some cases to make a simple plug, which may be retained in position by being attached to a skeleton plate fitted with clasps. In other instances, however, it will be necessary to cover the whole of the palate—for example, where many or all of the natural teeth are lost. Some dentists do not *fill* the openings in the palate with vulcanite, but carry the plate clear across in a line with its palate border. Professor Kingsley, however, says that it is desirable that the obturator should enter the perforation, to restore, as far as possible, the lost portion of the palate; but it ought not to protrude into or in any way obstruct the nasal passage, the entire freedom of which is essential to the purity of articulation.

Those cases in which the defect is situated in the soft palate require a more complicated appliance than that just described, in order that the motion of which these parts are capable may not be interfered with, which would be the case if the opening was filled by an extension simply of the rigid palate plate.

We have, then, first a main plate, which extends more or less over the hard palate, and which must sit steadily in position; second, we have the obturator or plug fitting into the opening in the soft palate. What is required then is to unite the one to the other in a sufficiently secure manner and yet allow to the obturator perfect freedom to take part in the muscular movements of the soft parts with which it is associated. Several contrivances have been tried in order to accomplish this; the most common of these methods are spiral springs,

band gold, and a simple joint. Of these, the last arrangement is the most satisfactory. The band gold if made sufficiently delicate will not maintain its shape, and if made sufficiently strong for that purpose it is then wanting in the elasticity necessary to permit the perfect motion of the obturator. The spiral spring arrangement is also objectionable, though less so than the band gold. A case constructed with a joint is shown in Fig. 86. The skeleton plate is made of gold, the joint also and the strip of metal reaching to the obturator are made of the same metal. The obturator B is made of vulcanite, and it will be observed that the material enters the opening and forms a flange (C in the smaller figure) around its superior or nasal border. This flange supports the obturator in position, and the joint, which should be placed at the junction of the hard and soft palates, permits the necessary motion.

Fig. 86. Obturator attached to Skeleton Gold Plate.

For cases belonging to the third species of accidental fissure—those in which a partial or complete destruction of the soft parts of the palate has taken place—a substitute must be made of a soft and elastic material; the delicate parts with which it must come into contact renders this essential. Soft rubber is admirably adapted for the purpose, and of that material all artificial palates or vela are now made.

Fig. 87 represents a case in which the entire soft palate is gone. Here a substitute is formed very simply by securing an apron of soft rubber along the posterior or palate border of an ordinary set of teeth. Fig. 88 represents the appliance attached. A sufficient number of small holes having been made along the edge of the plate, the at-

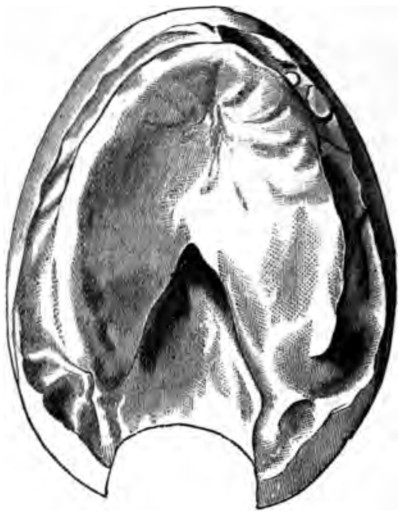


Fig. 87. Model of Defective Palate.

tachment is completed by stitching the soft rubber plate to the other by means of silk or fine platina wire.

In this case, the muscles of the palate being entirely gone, there is no necessity to provide specially for the perpendicular movement of the substitute. Where there is only partial destruction

of the soft palate, however, as in Fig. 89, an appliance is made upon the same principle as that explained in connection with Fig. 86. Fig. 90 shows this palate connected with an upper set of teeth. The following explanation of parts is given in Richardson's "Mech. Dent.," p. 420. "The wings marked A and B are made of soft rubber; the frame to support them is made of gold, with a

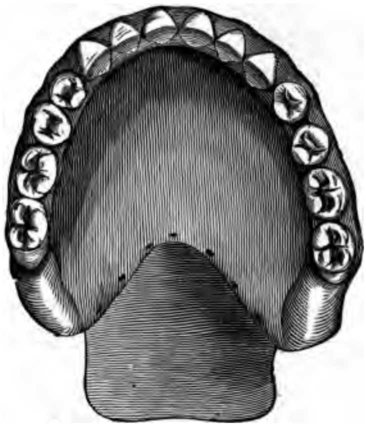


Fig. 88. Artificial Set of Teeth, with palate attached.

joint to provide for the perpendicular motion of the natural palate," as in the case of the obturator represented in Fig. 86. "When the artificial palate is in use, the joint and frame immediately contiguous lie close to the roof of the mouth; the rubber wing, letter A, bridges across the opening on the inferior surface or side next the tongue; the wing, letter B, bridges across the opening on the superior or nasal surface, and is

also prolonged backward until it nearly touches the muscles of the pharynx when they are in repose.

Fig. 89. Model of Defective Palate.

Both these wings reach beyond the boundary of

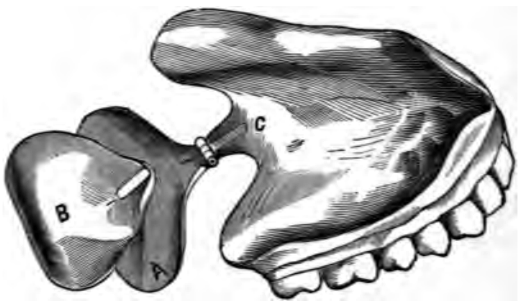


Fig. 90. Set of Teeth and Artificial Palate attached by joint.

the opening and rest on the surface of the soft palate for a distance of from one-eighth to one

quarter of an inch, thus embracing the entire free edge of the soft palate. This last provision enables the natural palate to carry the artificial palate up or down, as articulation may require.

When the organs of speech are in repose, there is an opening behind the palate sufficient for respiration through the nares. When these organs are in action, a slight elevation of the palate, or a contraction of the pharynx, will entirely close the nasal passage and direct all the voice through the mouth. The palate thus becomes a valve to open or close the nares, and to be tolerated must be made with thin and delicate edges which will yield upon pressure. An instrument thus made will restore, as far as possible by mechanism, the functions of the natural organ.

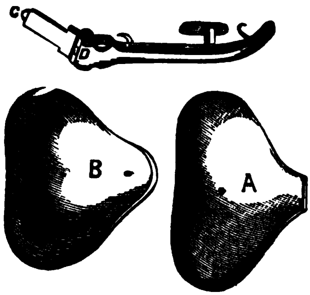


Fig. 91. Parts of which Artificial Palate (Fig. 90) is composed.

In the case under description the patient was a lady. The defect had existed for seven years before remedy. Articulation was very defective; distinct and perfect articulation followed within one month.

Fig. 91 represents the artificial palate separated into its constituent parts. The frame is bent at the joint, in the engraving, to show a stop, marked D, which prevents the appliance from dropping out of position. Letter C shows the tongue, which enters the groove in the plate of teeth and connects them. Letters A and B are the rubber flaps which are

secured to the frame by the hooks, as seen in the engraving."

We now come to consider the second class of palatal defects.

Congenital Fissures.—It has been already observed that many dentists treat these cases practically as those are treated which have an accidental origin. The opinion has long been held, however,

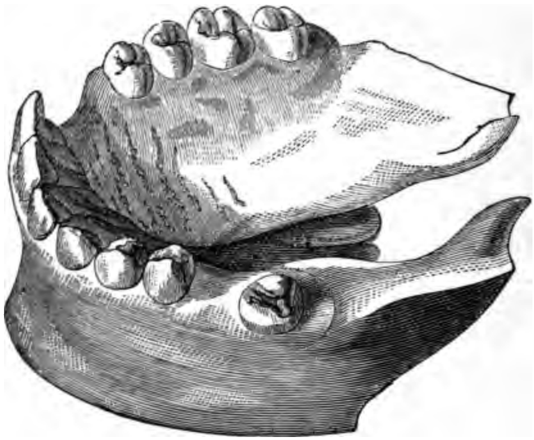


Fig. 92. Model of a Case of Congenital Fissure.

that a different arrangement is necessary—an arrangement by which the parts which have not been developed naturally shall be as far as possible represented artificially, and in such manner that the functions which would have been performed by the natural organs shall be performed by the artificial substitute. This was the principle according to which Stearns constructed his most ingenious

though complicated appliance, by which he provided that the muscular action which arose in the remaining parts of the soft palate should be communicated to the artificial substitute. Thus the natural parts were utilised as a motive power, as it were, to set the artificial material in motion, and make it accomplish the functions of a natural palate.

The Stearns instrument has now been superseded, however, by an appliance made according to the same theory, and which accomplishes the same

Fig. 93. Artificial Appliance for Congenital Fissure.

object, while at the same time it is much less complicated in its construction. Fig. 92 represents a case of congenital fissure, and Fig. 93 an artificial palate of this description made for the case by Dr. Kingsley.*

Here it will be observed that the letters B, D D, A A, indicate the parts which make up the palate substitute. These parts are made of soft rubber,

* Professor Kingsley, with whose name this description of artificial palate is identified, contributes a chapter upon this subject to Richardson's "Treatise on Mechanical Dentistry" (p. 415). To that chapter we are indebted for the details and illustrations connected with this process.

and the whole may be removed from the main plate, to which the appliance is connected only by the pin C. This pin is securely fixed at one extremity in the main hard rubber plate—which carries the teeth and is continued back under D C in the figure—at the other extremity C the head is considerably larger than the rest of the pin. Now the main plate having been constructed with this up-

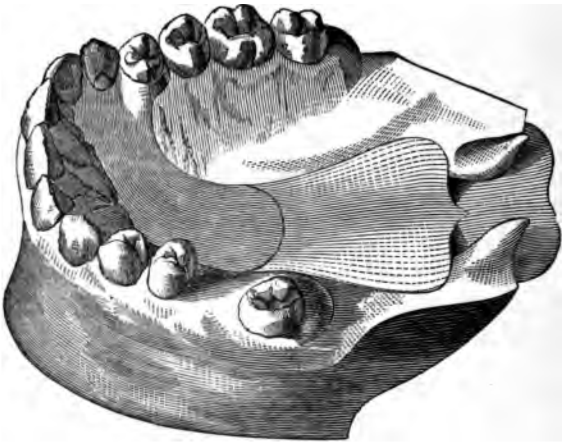


Fig. 94. Artificial Appliance in position upon model.

standing gold pin, and the artificial palate having been constructed with a hole through its elastic substance *exactly* according with the pin in position, but smaller in diameter, the latter is then forced through the hole in the artificial palate, and the arrangement of parts is obtained as shown in Fig. 93. The elasticity of the soft rubber permits the large-headed pin, C, to pass, and at the same

time the contracting force upon the latter is sufficient to fix the parts securely together. The wings D D reach over the inferior or palate surface of the fissure; A A is a similar plate, but more delicately formed, reaching across the pharynx, at the base of the chamber of the pharynx, behind the remnant of the natural velum. These wings, in their relation to the natural parts and to the main plate of hard rubber, will be best observed in Fig. 94. The process B laps over the inferior surface of the maxilla (the floor of the nares) and prevents all inclination to droop.

Method of Construction.—Taking the impression in such cases, it will be at once seen, is an operation which involves peculiar difficulties and which demands special care. Plaster of Paris is the only material which can be successfully employed for this purpose. Professor Kingsley says in regard to the parts of which an impression is necessary, and also as to the method to be employed in order to obtain the impression: "It is essential that the entire border of the fissure from the apex to the uvula should be perfectly represented in the model as the parts are when in repose. It is also necessary that the model show definitely the form of the cavity above, and on either side of the opening through the hard palate, being that part of the cavity which is hidden from the eye. It is desirable also that the posterior surface of the remains of the soft palate be shown, but this is not essential; but it is especially important that the anterior or under surface be represented with relaxed muscles and in perfect repose. The impression for

such a model must be taken in plaster; it is the only material now in use adapted to the purpose. An ordinary Britannia impression-cup may be used, selecting one in size and form corresponding to the general contour of the jaw. This cup will be found too short at the posterior edge to receive the palate, but it may be extended by the addition of a piece of sheet gutta-percha, which must be moulded into such form as not to impinge upon the soft palate, but which will reach under and beyond the uvula, and thus protect the throat from the droppings of plaster. Before using the plaster the posterior edge of the gutta-percha extension may be softened by heat and introduced into the mouth; contact with the soft palate will cause it to yield, so that there is no danger of its forcing away the soft tissues when the plaster is used. With the precaution not to use too much plaster, the first effort will be to get only the lingual surface. After trial, if the impression show definitely the entire border of the fissure, and the soft palate has not been pushed up by contact with the cup, nor pulled up by the spasmodic action of the levator muscles, it is all that is thus far desired. If, however, the soft parts have been disturbed (which on close comparison a little experience will decide), it is better to cast a model into the impression, and upon this model extemporize an impression-cup (in the manner already explained in connection with obturators, p. 183). This temporary cup will have the advantage of the former, insomuch that it will require but a film of plaster to accomplish the result, thus lessening the danger of disturbing the soft tis-

sues. After the removal, if it is seen that any surplus has projected through the fissure and lapped to the floor of the nares, it may be pared off.

The next step will be to obtain, in conjunction with this impression of the under surface, which we will call the palatal impression, an impression of the upper or nasal surface of the hard palate.

This can be done by filling the cavity above the roof of the mouth with soft plaster down to the border of the fissure, and, while yet very soft, carrying immediately the palatal impression against it, and retaining it in that position until the plaster is hard, which can easily be ascertained by the remains in the vessel from which it was taken. With the precaution to paint the surface of the palatal impression with a solution of soap, to prevent the two masses from adhering when brought into contact, there will be no difficulty in removing it from the mouth, leaving the mass which forms the nasal portion *in situ*. With a suitable pair of tweezers this mass is easily carried backward and withdrawn from the mouth, and the irregular surface of contact indicates its relation to its fellow when brought together.

Fig. 95 shows such an impression. The portion marked A B C will readily be distinguished as that which entered the nasal cavity. The line of separation from the palatal impression is plainly indicated. The groove marked D shows clearly the impression made by the delicate uvula in the soft plaster. The nasal portion is relatively large, showing an unusally large nasal cavity.

The vomer lies between the projections marked

A A, these projections entering the nasal passages. The surfaces marked B B came in contact with the middle turbinated bones, the surface marked C in contact with the inferior turbinated bone. In many instances these turbinated bones are so large as to nearly fill the nasal passages."

Casting a model in plaster from the impression is accomplished in a manner similar to that explained in connection with ordinary work, the parts of the plaster marked A B C being withdrawn from beneath towards the back of the model

Fig. 95. Plaster Impression for a Case of Congenital Defect.

after casting and separating. The latter should then be somewhat similar in appearance to Fig. 92.

Should the nasal portion of the impression not indicate accurately the superior surface of the soft palate, that part may be carved as near as possible to the dimensions required, the indications of which may be obtained by the aid of a small mirror and probe. It is next necessary to make to the model a pattern of the intended appliance; the best material to use for this purpose is sheet gutta-percha. The form to be given is sufficiently

indicated in Fig. 93. A mistake which is sometimes made is to bring the soft rubber through the opening so as completely to fill the cleft from side to side. By reference to the figures it will be seen that this is carefully avoided. It must be remembered that while the hard palate is incapable of muscular action, and therefore permits us to bring the rubber through the cleft, as at B C, in order to obtain a hold for the case, the soft palate which commences at the posterior boundary of B C is capable of muscular action; the sides, for example, approach towards each other, and therefore only a thin partition of rubber is permissible, in order that that movement may not be interfered with. Other movements besides this one must be provided for by making the wing A very thin and delicate; it occupies the chamber of the pharynx, and is subject to constant muscular movement. "The sides are rolled slightly upward while the posterior end is curved downward. The inferior portion marked D D should only reach to the base of the uvula, and bridge directly across the chasm at this point, and no effort to imitate the uvula should be made. The extreme posterior end should not reach the posterior wall of the pharynx when all the muscles are relaxed by a quarter of an inch, although subsequent use must determine whether this space be increased or diminished, thus leaving abundant room for respiration and the passage of nasal sounds. In cases where it is desirable to make the instrument independent of the teeth as far as possible in its support, the anterior part which occupies the apex of the fissure

in the hard palate may lap over on to the floor of one or both nares. Such a projection is seen in Fig. 93 marked B, and a like process is seen in Fig. 98 but not lettered. Were it not for this process in this case the palate would drop out of the fissure into the mouth, the single clasp at the extreme anterior end not being sufficient to keep the whole appliance in place throughout its entire length. Caution must be exercised that this projection entering the nares be not too large, or it will obstruct the passage and give a disagreeable nasal tone to the voice.

"All these described peculiarities must be provided for in the gutta-percha pattern, which, after having been carefully formed to the cast, may be tried in the mouth to ascertain its length or necessary variations. When its ultimate form has been decided upon, provision must be made to duplicate it in soft rubber."

To make a satisfactory duplicate in soft rubber, type metal models must be used to fire upon instead of the plaster one, as with ordinary work, for this reason: the plaster leaves an unfinished surface, which in hard rubber may be dressed, but in soft rubber can not. Professor Kingsley advises, however, that as it is difficult for a beginner to give the necessary delicacy of form to the gutta-percha pattern, a hard vulcanite pattern piece should be made from the gutta-percha one, using plaster and a flask as in ordinary work; the hard rubber may then be easily dressed to the delicate shape required for the artificial palate. After a little practice in the work vulcanite patterns may be dispensed with.

To obtain in soft rubber a duplicate which will consist of one continuous piece requires a mould to be made of the pattern in four pieces. This is the most desirable form in which to make the appliance, but to make such a mould requires considerable mechanical skill, in order that all the parts may fit accurately together. Therefore Professor Kingsley advises beginners to make the palate in *two* pieces instead of one continuous piece. By adopting this method it can be constructed with

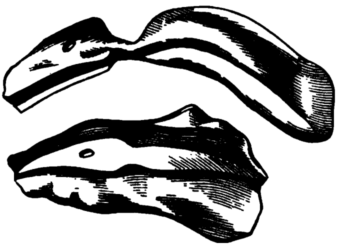


Fig. 96. Artificial Palate made in two pieces.

very little trouble. The mould is also made in two pieces, and, after vulcanizing, the palate pieces are joined.

Fig. 96 shows a palate prepared in this manner.

Fig. 97 shows the mould or flask in which it is vulcanized.

"These flasks," says the same author, "were made expressly for this purpose, but they are not so unlike the flasks in common use in dentists' laboratories that the latter will not answer. The common flask is simply unnecessarily thick or deep.

"The mould is readily produced in the following manner. Imbed the two pieces of the palate in

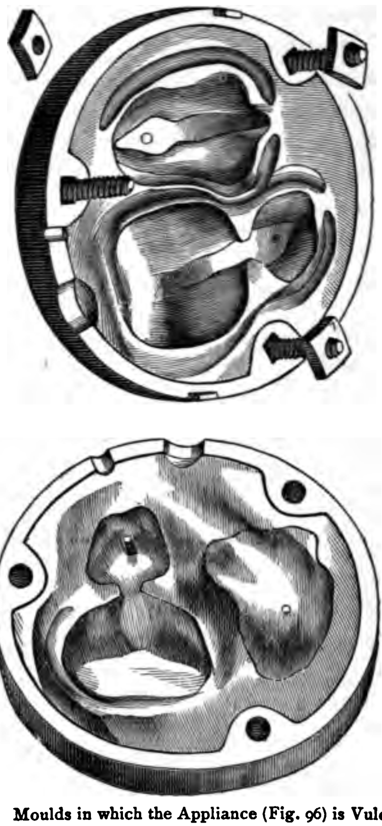


Fig. 97. Moulds in which the Appliance (Fig. 96) is Vulcanized.

plaster in one half of the flask; when the plaster is set and trimmed into form, duplicate it in type metal by removing the palate, varnishing the sur-

face, moulding in sand, and casting. In making the sand mould, take a ring of sheet iron of the same diameter as the flask and three or four inches high, slip it over the flask, and pack full of sand. Separate them, remove the plaster, return the flask to the sand mould, and fill with the melted metal through a hole made in the side or bottom of the flask. With one-half thus made, substantially the same process will produce the counterpart. Fig. 98 shows the palate complete with its attachment to the teeth. The palate is secured to the plate by a pin of gold passing through a hole in

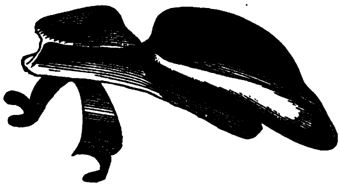


Fig. 98. Appliance completed and ready for insertion.

the palate of the same size, the head on the pin being larger than the hole it is passed through, and thus the two halves of the palate are bound together and joined to the plate.

"Fig. 99 shows a mould in four pieces. The blocks C C are accurately adapted to the body of the mould marked A, and are prevented from coming improperly in contact with each other by the flanges D D, which overlap and rest upon the sides of the main piece. B shows the top of the mould, and the groove E provides for the surplus rubber in packing.

"Such a mould makes the most perfect appliance

that can be produced. The palate is one homogeneous and inseparable piece. The cut will sufficiently indicate the forms of the several parts. Each of these pieces is first made in plaster of

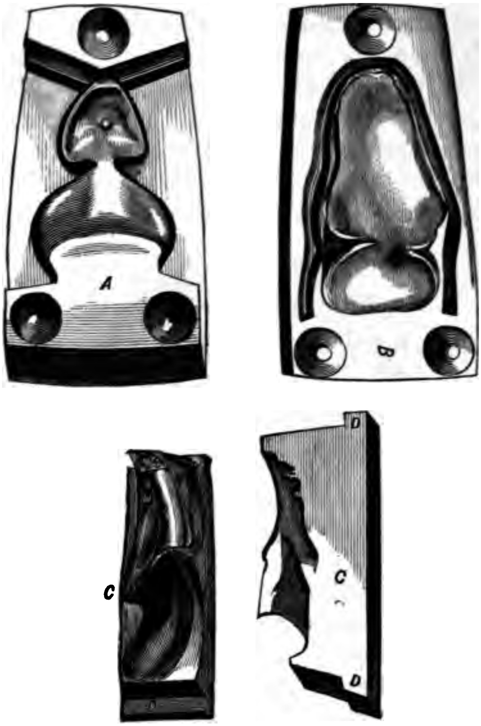


Fig. 99. Moulds required in order to make Palate in one piece.

exactly the form of which the type metal is desired. They are then moulded in sand, and the type metal cast as in making an ordinary die for swaging."

When the parts have been obtained in metal

and *accurately* fitted, it is then necessary to pack with the *soft* rubber in a manner similar to that adopted in ordinary work. If the surface of the metal be washed with a thick solution of soap previous to packing, the palate will be more easily removed after vulcanizing.

The soft rubber which we have found best adapted for this work is that known as "Mr. Ramsey's." It may be purchased at the depôts. Much longer time must be given for vulcanizing this

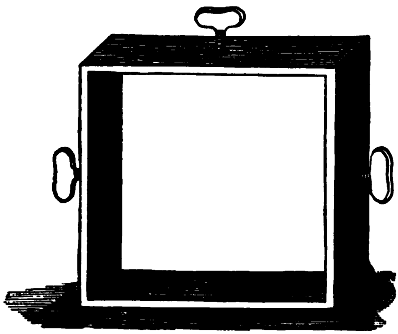


Fig. 100. Frame in which the Mould is held during Vulcanizing.

material than what is required for the ordinary hard rubbers, and the temperature must not rise above 280° Fah. That recommended by Mr. Ramsey is—two hours at 240°, two hours at 260°, and two hours at 280°. In all six hours after the temperature has reached 240°. Dr. Kingsley found that for the soft rubber sold by the American Company the best vulcanizing time is four or five hours, during which time the heat should rise gradually from 230° to 270°.

CHAPTER XV.

VULCANITE.

CAOUTCHOUC, gum-elastic, or india-rubber, occurs as a milky juice in several plants; it is, however, extracted chiefly from the *Siphonia elastica*, which grows in South America and Java. Incisions are made into the bark of the tree, and the juice, which is by this means discharged, is spread upon clay moulds, and dried in the sun, or with the smoke of a fire, which blackens it.

"The specific gravity of caoutchouc is 0·925, and it is not permanently increased by any degree of pressure. By cold or long quiescence it becomes hard and stiff. When the milky juice has become once coherent, no means hitherto known can restore it to the emulsive state. By long boiling in water it softens, swells, and becomes more readily soluble in its peculiar menstrua; but when exposed to the air it speedily resumes its former consistence and volume. It is quite insoluble in alcohol; but in ether deprived of alcohol by washing with water it readily dissolves, and affords a colourless solution. When treated with hot naphtha, distilled from native petroleum or from coal tar, it swells to thirty times

its former bulk; and if then triturated with a pestle and pressed through a sieve it affords a homogeneous varnish, which being applied by a flat edge of metal or wood to cloth, prepares it for forming the patent waterproof cloth of macintosh. Two surfaces of cloth, to which several coats of the above varnish have been applied, are, when partially dried, brought evenly in contact, and then passed between rollers in order to condense and smooth them together. This double cloth is afterwards suspended in a stove-room to dry and to dispel the disagreeable odour of the naphtha.

"The best solvent is a mixture of 100 parts of bi-sulphide of carbon, with from 6 to 8 parts of anhydrous alcohol.

"**Vulcanization.**—Of all the changes effected by chance, observation, or chemial experiments of late years, few cases have been so important as the change in india-rubber by the process called vulcanization.

"When caoutchouc is mixed with from 2 to 10 per cent. of sulphur, and then heated to 270° and 300°, it undergoes a change, it acquires new characters, its elasticity is greatly increased and is more equable; it is not affected nor is the substance altered by cold, no climate effects a change, heat scarcely affects it, and when it does it does not become sticky and a viscid mass; if it yields to a high temperature it is to become harder, and will ultimately yield at the advanced temperature to char and decompose." *

The first movement towards this new manufacture

* Ure's Dictionary.

appears to have been made in America by Mr. Goodyear, who, having made a contract for india-rubber mail bags, found that they "softened and decomposed in service, and while he thought a permanent article had been made, the colouring materials and the heat united to soften and to destroy the bags; hence by this failure distress of all kinds arose, and the trade was at an end." This moved Mr. Goodyear to make certain experiments. He tried heating the substance, and found it charred like leather instead of melting as gum elastic does, when exposed to a high heat. The idea thus gained was the germ from which the process of vulcanization was derived.

The mixture of sulphur and other substances with the india-rubber was not new, several patents having been taken out in England and America for mixing with these substances, simply in order to get rid of the tendency which the pure or unmixed rubber has to adhere. But no one had any idea that heat would make a further and remarkable change upon this mixed substance, until Goodyear accidentally discovered the new fact. "The general method is to incorporate sulphur with caoutchouc, and submit it to heat; if any particular form is required, the mixture is placed in moulds, and takes off any delicate design that may be upon the metal mould, and if these are submitted to higher degrees of heat, the substance and evolved gases expand, and thus a very hard, horny, and light, but very strong substance is produced, called hard india-rubber, or 'vulcanite.'" The term vulcanization was given by Mr. Brockedon to this process, which

seemed by the employment of heat and sulphur to partake of the attributes of the Vulcan of mythology. For the "change" or "vulcanizing," to get a yielding but permanently elastic substance, steam heat is usually employed in England, but in America ovens with various plans for producing dry heat are generally employed.

TABLE OF ELASTIC FORCE OF STEAM, QUOTED FROM RESULTS OF THE EXPERIMENTS OF THE COMMISSION OF THE FRENCH ACADEMY APPOINTED BY THE FRENCH GOVERNMENT TO INVESTIGATE THIS SUBJECT.

Elasticity of Steam taking Atmospheric Pressure as Unity.	Temp. Fah.	Pressure per sq. in. in lbs.
	deg.	deg.
1	212	14·7
1½	233·96	22·05
2	250·52	29·4
2½	263·84	36·75
3	275·18	44·1
3½	285·08	51·45
4	293·72	58·8
4½	300·28	66·15
5	307·05	73·5
5½	314·24	80·85
6	320·36	88·2
6½	326·26	95·55
7	331·7	102·9
7½	336·86	110·85
8	341·78	117·6
9	350·78	132·3
10	358·88	147
11	366·85	161·7
12	374	176·4
13	380·66	191·1
14	386·94	205·8
15	392·86	220·5
16	398·48	235·2
17	403·82	249·9
18	408·92	264·6
19	413·78	279·3
20	418·46	294

The above table shows that the pressure upon the vulcanizer increases at a much greater rate than the temperature.

Degrees.	Incr. of Temp.	Incr. of Force per sq. in.	Giving a Force per sq. in.
From 212 to 263·84	= 51·84 . . .	22·05 lbs. . . .	36·75 lbs.
263·84 to 314·24	= 50·40 . . .	44·10 „ . . .	80·85 „
314·24 to 366·85	= 52·61 . . .	80·85 „ . . .	161·85 „
366·85 to 418·46	= 51·61 . . .	132·15 „ . . .	294·00 „

Thus we find that while the temperature increased from 263° to 418° at the rate of only 60 per cent., the pressure or force exerted by the steam within the chamber after that increase of heat was at the rate of 600 per cent.

CHAPTER XVI.

METALS USED IN DENTISTRY.

Gold.—(Sym., Au.; At. wt., 19·7).—Gold has now been detected in almost every kind of rock, and in all parts of the world; but it is usually found associated with the older rocks and in the sands of those rivers which pass through them. It is chiefly met with in the metallic state, sometimes crystallized in cubes and its derivative forms. It also occurs in threads of various sizes, twisted and interlaced into a chain of minute octahedral crystals, and in spangles or rounded grains, which are called nuggets when of a certain size. The small grains are not fragments broken from a greater mass, but show by their flattened ovoid shape and their rounded outline that this is their original shape.*

Pieces of gold weighing more than a few ounces have rarely been met with in nature, yet some of considerable size have been recorded. In Siberia, according to Humboldt, large pieces have been found; the largest weighed 27 lbs., and is in the Imperial Museum. A piece weighing 28 lbs. was

* Kerl's "Metallurgy."

found in 1828 at Reid's mines, Cabarras County, North Carolina. In the drift near La Paz, in Peru, a mass 59 lbs. in weight was obtained; whilst in our own colonies one weighing 106 lbs. was dug out of the quartz rock near Bathurst. The latter contained upwards of 91 per cent. of pure gold and nearly 8⅓ per cent. of silver, being as pure as the English sovereign.*

Physical Properties of Gold.—Pure gold is softer than silver, and possesses malleability and ductility in a greater degree than any other metal. It may be beaten into leaves so thin as to require 251,154 folds to make one inch in thickness. The coating of gold upon ordinary gold lace is yet thinner, because in making it a small cylinder of silver is covered with 1-48th its weight of gold, and drawn into wire which is rolled until 11·8 feet in length weigh but one grain.

Reamur covered a cylinder of silver with 1·360 its weight of gold. It was drawn into a wire, of which 6 feet weighed one grain, and then rolled to a width of 1-48th of an inch, which increased its length to 7·5 feet; and yet the silver was so completely covered that the microscope failed to detect the least appearance of it. The tenacity of gold is less than that of platinum, copper, and iron. A weight of 173·3 lbs. is sufficient to break a wire whose diameter is 0·0784 inch, or nearly 1-13th of an inch. Its tenacity is lessened by hammering, but its stiffness and elasticity are increased. The tenacity may be restored by exposing the metal to sufficient heat.

* Cooley, "Cyclop."

Whilst passing from the liquid state it contracts more than any other metal. According to Berthier the specific gravity of gold after melting is 19·258. This density is increased in proportion as it is hammered, the maximum being given as 19·65.

For a detailed account of the metallurgical process of refining gold, as well as for the methods adopted by the assayer, we would refer the reader to the "Manual of Metallurgy," by Makins, or Ure's "Dictionary of Arts;" a description of the humid process of refining, however, which the dentist might wish to adopt for intractable scrap or lemel, is here given.

To refine Gold by the Humid Process.—To accomplish this the metal must be submitted to the action of either nitric acid or of aqua regia. If it be intended to use the nitric, then the gold must first be melted along with an excess of silver (2½ silver to 1 part gold), and the alloy should be granulated by pouring the melted metal from a considerable height into a deep vessel of water. The grains having been carefully collected are then placed in a basin or suitable German flask, and treated with nitric acid, as follows:—

Alloy of gold	1 oz.
Nitric acid (sp. grav. 1·3) . .	2½ to 3 ozs.

The time required for the acid to do its work of dissolving the silver depends upon its temperature; if cold it will require several hours, but if it be heated to boiling the action is very rapid. The fluid, after this has been satisfactorily accomplished, is poured off into a second basin, and the gold may be subjected to the action of a smaller

quantity of fresh nitric acid; this, when it has done its work, is also poured into the second basin; the gold remaining in the first is then carefully washed and dried, when it is placed in a crucible and melted with a little borax; the resulting "button" of gold is then alloyed, melted, and poured, as already described at p. 35.

The silver which is held in solution in the nitric acid poured off, is precipitated by adding common salt, which throws the metal down in the state of white powder. Before adding the salt dilute the acid copiously with water.

The precipitated metal is washed and dried, and melted in the same manner as the gold.

In refining by means of aqua regia the gold requires no addition of silver to be made to it; but it should be rolled very thin, or granulated, before submitting it to the acid. Aqua regia is composed of 3 parts of hydrochloric acid and 1 of nitric. For 1 oz. of gold alloy, use 4 ozs. of aqua regia. The flask is then heated on a sand bath, and when the desired effect has been produced the solution is poured off; and the residue of chloride of silver is boiled again with a smaller quantity of aqua regia, then washed with distilled water and reduced. The gold held in the solutions poured off is precipitated by adding protosulphate of iron dissolved in clean rain-water. "It is to be added gradually to the gold solution as long as a precipitate is found, and even longer, as an excess will the better insure the precipitation of all the gold. The gold thus precipitated is a brown powder, having none of the appearances of gold in its ordinary state.

The solution should now be filtered, or the gold should be allowed to settle to the bottom, where it may be washed after pouring off the solution. It is better to filter than decant in this case, as frequently particles of the gold float on the surface, and would be lost in the washing by the latter process.

"Minute traces of iron may adhere to the gold thus precipitated. These can be removed by digesting the gold in dilute sulphuric acid, and when the process is properly conducted thus far the result is *pure gold*, which may be melted under carbonate of potash, in a crucible lined with borax, and reduced to the required carat." *

"The chloride of silver may be reduced by melting it with carbonate of potash or, better—according to Guy Lussac—with freshly burned lime." †

TO CALCULATE THE AMOUNT OF ALLOY REQUIRED FOR GOLD PLATE.

[The following table is given by Professor Austen, and shows the amount of fine gold in the various carats.]

	Fractions.	Carats.	Decimals.
Pure gold	1	24	1000
English coin	$\frac{11}{12}$	22	916·6
American coin	$\frac{9}{10}$	21·6	900
Dentists' gold, best	$\frac{5}{6}$	20	833
" " good	$\frac{4}{5}$	19·2	800
Jewellers' gold, best	$\frac{3}{4}$	18	750
" " good	$\frac{5}{8}$	15	625
" " common	$\frac{1}{2}$	12	500
Commonest solder	$\frac{1}{3}$	8	333·3

* Prof. Watts, "Dental Register of the West."

† Kerl, "Treatise on Metallurgy."

The table gives the amount of pure gold, subtracting which from the number at the head of each column will give the amount of alloy. For example, the best jewellers' gold contains 18 carats of pure gold; subtract 18 from 24, the number at head of column, gives 6 parts of alloy; or take the fraction column, $\frac{3}{4}$ pure gold and $\frac{1}{4}$ alloy; or the decimals, 750 parts pure gold and 250 parts alloy.

Various formulæ are given for reducing gold from a higher to a lower standard. The following is by Professor Austen: "Divide the lower carat (*c*) by the difference between the lower carat (*c*) and the higher (C); divide the weight (w) of the gold by this quotient, and it will give the amount of alloy to be added. This expressed in algebraic formula is—

$$A = W \div \frac{c}{C - c}$$

Suppose the weight is 20 dwts., the carat 24, it is required to reduce this to 18-carat gold; divide the weight 20 by 3 (which is the quotient after dividing the lower carat by the difference between the lower and the higher), this gives 6 dwts. 16 grs. as the amount of alloy required."

Professor Watt* gives the following formula: "To reduce gold to a required carat, the proportion may be expressed as follows: as the required carat is to 24, so is the weight of the pure gold used to the weight of the alloyed mass when reduced. The weight of gold subtracted from this

* "Dental Register of the West."

gives the quantity of alloy to be added. For example, reduce 6 ozs. of pure gold to 16 carats.

16 : 24 :: 6 : 9

Six subtracted from 9 leaves 3, which is the quantity of alloy to be added. As another example, reduce 1 dwt. of 22-carat gold to 18 carat. As the gold is only 22 carats fine 1-12th of it is already alloy. The 1 dwt. therefore contains but 22 grs. of gold. The statement is therefore thus expressed—

18 : 24 :: 22 : 29⅓

Twenty-two subtracted from 29⅓ leaves 7⅓. Therefore each dwt. of 22-carat gold requires 7⅓ grs. of alloy to reduce it to 18 carats."

To ascertain the Carat of any given Alloy.—As the weight of the alloy is to the weight of gold it contains, so is 24 to the standard sought. For example, take Harris's No. 3 gold solder:—

Pure gold	6 parts.
Pure silver	2 ,,
Pure copper	1 ,,
Total	9 ,,

The proportion would be expressed thus:—

9 : 6 :: 24 : 16

As another example under the same rule take Harris's No. 1 solder:—

22-carat gold	48 parts.
Pure silver	16 ,,
Pure copper	12 ,,
Total	76 ,,

As the gold used is but 22 carats fine, 1-12th of it is alloy; 1-12th of 48 is 4, which subtracted from 48 leaves 44. The statement then is:—

$$76 : 44 :: 24 : 13{\cdot}9$$

The solder therefore falls a fraction below 14 carats.

To raise Gold from a Lower to a Higher Carat.—Gee gives the following. The numeral 20 represents 20 dwts. of gold, which is to be raised from 9-carat to 15-carat. The 15 represents the carat required; the 9 represents *the difference* between the required carat and 24.

$$\begin{aligned} 20 \times 15 &= 300 \\ 20 \times 9 &= 180 \\ 300 - 180 &= 120 \\ 120 \div 9 &= 13 \text{ dwts. } 8 \text{ grs.} \end{aligned}$$

"Therefore to every ounce of 9-carat gold we shall have to add 13 dwts. 8 grs. of fine gold to make 15-carat gold."*

Supposing we have a piece of gold of a certain carat, and we wish to raise it to a higher one, then the weight of the gold is multiplied by the required carat, also by the difference between the required carat and 24; the difference between the two products is then divided by that between the required carat and 24; the result gives the fine gold to be added.

* "Practical Goldworker" (Gee).

Gold Alloys.

Composition of a sovereign.

	ozs.	dwts.	grs.
Fine gold, per oz.	0	18	8
Refined copper	0	1	16
	1	0	0

Gold plate, 20 carats fine.

	ozs.	dwts.	grs.
Fine gold	1	0	0
Fine copper	0	2	0
Fine silver	0	2	0
	1	4	0

Gold plate, 20 carats fine, reduced from English coin.

	ozs.	dwts.	grs.
Four sovereigns	1	0	12
Fine copper	0	0	15
Fine silver	0	1	10
	1	2	13

Gold plate, 19 carats fine.

	ozs.	dwts.	grs.
Fine gold	0	19	0
Fine copper	0	3	0
Fine silver	0	2	0
	1	4	0

Gold plate, 19 carats fine, reduced from English coin.

	ozs.	dwts.	grs.
Four sovereigns	1	0	12
Fine copper	0	1	0
Fine silver	0	2	6
	1	3	18

Gold plate, 18 carats fine.

	ozs.	dwts.	grs.
Fine gold	0	18	0
Fine copper	0	4	0
Fine silver	0	2	0
	1	4	0

Gold plate, 18 carats fine, reduced from English coin.

	ozs.	dwts.	grs.
Four sovereigns	1	0	12
Fine copper	0	1	9½
Fine silver	0	3	2½
	1	5	0

Gold plate, 16 carats fine.

	ozs.	dwts.	grs.
Fine gold	0	16	0
Fine silver	0	4	0
Fine copper	0	4	0
	1	4	0

Gold plate, 16 carats fine, reduced from English coin.

	ozs.	dwts.	grs.
Four sovereigns	1	0	12
Fine silver	0	4	15
Fine copper	0	2	21
	1	8	0

Spring gold, for clasps, wire, &c., 20 carats fine.

	ozs.	dwts.	grs.
Fine gold	1	0	0
Fine copper	0	2	0
Fine silver	0	1	0
Platinum	0	1	0
	1	4	0

Spring gold, 16 carats fine.

	ozs.	dwts.	grs.
Fine gold	1	16	0
Fine silver	0	6	0
Fine copper	0	12	0
	2	14	0

Solders.

16 carats fine. Used with 20-carat plate.

	ozs.	dwts.	grs.
Fine gold	0	6	0
Roset copper	0	2	0
Fine silver	0	1	0
	0	9	0

15 carats fine (fraction over). Used with 18-carat plate.

	ozs.	dwts.	grs.
Fine gold	0	6	0
Fine silver	0	2	12
Fine copper	0	1	0
	0	9	12

15 carats fine (fraction over). Reduced from English coin.

	ozs.	dwts.	grs.
Sovereign gold	0	6	0
Fine silver	0	1	17
Fine copper	0	1	0
	0	8	17

The same reduced from 18-carat plate.

	ozs.	dwts.	grs.
18-carat gold	0	6	0
Fine silver	0	0	15
Fine copper	0	0	9
	0	7	0

Harris's fine flowing solders. No 1. Fraction below 14 carats.

	ozs.	dwts.	grs.
Sovereign gold	0	2	0
Fine silver	0	0	16
Roset copper	0	0	12
	0	3	4

No. 2. About 12½ carats.

	ozs.	dwts.	grs.
Sovereign gold	0	1	15
Fine silver	0	0	16
Roset copper	0	0	12
	0	2	19

The two last recipes are objected to by Richardson, as being too inferior in quality for dental work.

Brass or Zinc in Solder.—Richardson adds 10 grs. of brass to the 15-carat solders given above.

TABLE SHOWING THE PROPORTION OF ALLOY TO BE ADDED TO 1 OZ. OF STANDARD GOLD IN MAKING THE FOLLOWING QUALITIES.

Qualities.	Standard Gold.			Alloy added.			Total.		
Carats.	ozs.	dwts.	grs.	ozs.	dwts.	grs.	ozs.	dwts.	grs.
21	1	0	0	0	0	23	1	0	23
20	1	0	0	0	2	0	1	2	0
19	1	0	0	0	3	4	1	3	4
18	1	0	0	0	4	10	1	4	10
17	1	0	0	0	5	21	1	5	21
16	1	0	0	0	7	12	1	7	12
15	1	0	0	0	9	8	1	9	8

TABLE SHOWING THE PROPORTION OF ALLOY TO BE ADDED TO 1 OZ. OF FINE GOLD IN MAKING THE FOLLOWING QUALITIES.

Qualities.	Fine Gold.			Alloy added.			Total.		
Carats.	ozs.	dwts.	grs.	ozs.	dwts.	grs.	ozs.	dwts.	grs.
23	1	0	0	0	0	20	1	0	20
22	1	0	0	0	1	18	1	1	18
21	1	0	0	0	2	20	1	2	20
20	1	0	0	0	4	0	1	4	0
19	1	0	0	0	5	6	1	5	6
18	1	0	0	0	6	16	1	6	16
17	1	0	0	0	8	5	1	8	5
16	1	0	0	0	10	0	1	10	0
15	1	0	0	0	12	0	1	12	0

TABLE GIVING THE WEIGHTS OF PIECES OF GOLD OF THE SAME DIMENSIONS, BUT OF DIFFERENT CARAT VALUE.

Qualities.					ozs.	dwts.	grs.
24	carat	of given	dimensions	will weigh	1	0	0
23	,,	,,	,,	,,	0	19	12
22	,,	,,	,,	,,	0	19	0
20	,,	,,	,,	,,	0	18	0
18	,,	,,	,,	,,	0	17	12
15	,,	,,	,,	,,	0	16	0
13	,,	,,	,,	,,	0	15	0
12	,,	,,	,,	,,	0	14	12
10	,,	,,	,,	,,	0	14	0
9	,,	,,	,,	,,	0	13	12
8	,,	,,	,,	,,	0	13	0
7	,,	,,	,,	,,	0	12	12

From the above table an approximate estimate, therefore, may be made of the value of any piece of gold.

TABLE OF VALUE.

Qualities.					£	s.	d.
24-carat	gold	costs	per	oz.	4	6	0
23	,,	,,	,,	,,	4	2	6
22	,,	,,	,,	,,	3	19	0
21	,,	,,	,,	,,	3	15	6
20	,,	,,	,,	,,	3	12	0
19	,,	,,	,,	,,	3	8	6
18	,,	,,	,,	,,	3	5	0
17	,,	,,	,,	,,	3	1	6
16	,,	,,	,,	,,	2	18	0
15	,,	,,	,,	,,	2	14	6
14	,,	,,	,,	,,	2	11	0
13	,,	,,	,,	,,	2	7	6
12	,,	,,	,,	,,	2	4	0
11	,,	,,	,,	,,	2	0	6
10	,,	,,	,,	,,	1	17	0
9	,,	,,	,,	,,	1	13	6
8	,,	,,	,,	,,	1	10	0
7	,,	,,	,,	,,	1	6	6

Platinum.—(Sym., Pt.; At. wt., 98·5).—"A metal of a greyish white colour, harder than silver, and of about double its density, being of specific gravity 21. It is so infusible that no considerable portion of it can be melted by the strongest heats of our furnaces. It is unchangeable in the air and water, nor does a white heat impair its polish. The only acid which dissolves it is the nitro-muriatic (aqua regia).

Great improvements in refining platinum have been introduced by Messrs. Deville & Debray. In a furnace composed of blocks of lime the platinum is fused by means of the oxyhydrogen flame." *

* Ure's "Dictionary of Arts."

Platinum Alloys.—7 parts of platinum and 3 *gold* form an alloy infusible in the strongest blast-furnace. Alloys containing a large proportion of gold fuse at that degree of heat (Prinset). 2 parts platinum and 1 gold form a brittle alloy; 1 part platinum and 1 gold form a very malleable alloy having nearly the same colour as gold. The alloy of 1 part platinum and 9·6 gold has the colour of gold and the density of platinum. 1 part platinum and 11 gold form a greyish white alloy, like tarnished silver.

Silver unites with platinum in all proportions. A very small quantity renders silver hard. Hot oil of vitriol dissolves out the silver from the alloy and leaves the platinum.

With *copper*, platinum does not combine below a white heat.

Lead unites very easily with platinum. 1 part of spongy platinum and 2·7 of lead heated to redness together combine without visible combustion, and form an easily fusible compound which has the colour of bismuth, splits under the hammer, and exhibits a fibrous texture.

Equal parts of platinum and *palladium* unite somewhat below the melting point of the latter, forming a grey alloy as hard as wrought iron, having a specific gravity of 15·141, less ductile than the alloy of palladium and gold.

Palladium.—(Sym., Pd.; At. wt., 53·36).—The specific gravity of palladium is 11·8 to 12·14. It is found in native platinum, also as an alloy with gold, in Brazil, and in many varieties of native gold. It is one of the hardest of the metals;

colour not so bright as that of silver; it is malleable, ductile, and capable of being welded. Palladium is more oxidisable than silver, for it tarnishes in air at the ordinary temperature. When heated in air it becomes blue at first from partial oxidation; but if the temperature be increased, this colour disappears and its brightness returns. It is remarkable that, though silver tarnishes, and palladium does so in a still greater degree, an alloy of the two metals does not tarnish, and such an alloy is on account of this valuable property frequently used by dentists as a base on which to mount the artificial teeth.

The union of palladium with gold injures the colour, and even 1 per cent. may be detected by sight and 5 per cent. renders it a silver colour, while about 10 per cent. destroys it; but the ductility of the alloy is not much injured.

The alloys of silver and palladium may be made in any proportions; it has been found that even 3 per cent. of palladium prevents silver tarnishing so soon as without it, 10 per cent. very considerably protects the silver, and 30 per cent. of palladium will prevent the silver being affected by fumes of sulphuretted hydrogen unless very long exposed. The latter alloy has been found useful for dental purposes, and the alloy with less proportions—say 10 to 15 per cent.—has been used for graduated scales of mathematical instruments.*

Silver.—(Sym., Ag.; At. wt., 10·8).—"When pure and polished, silver is the brightest of the metals. Its specific gravity in the ingot is 10·47; but

* Ure.

when condensed under the hammer or in the coining press it becomes 10·5. It melts at a bright red heat, at a temperature estimated by some as equal to 1,873° Fah. It is exceedingly malleable and ductile, affording leaves not more than $\frac{1}{100000}$ of an inch thick, and wire far finer than a human hair. By Sickington's experiments, its tenacity is to that of gold and platinum, as the numbers 19, 15, and 26¼, so that it has an intermediate strength between these two metals. Pure atmospheric air does not affect silver, but that of houses impregnated with sulphuretted hydrogen soon tarnishes it with a film of brown sulphide. It is distinguished chemically from gold and platinum by its ready solubility in nitric acid, and from almost all other metals by its saline solutions affording a curdy precipitate with a most minute quantity of sea-salt or any soluble chloride." *

Silver is used in combination with *palladium* in the proportion of 100 silver to 30 palladium, to form an alloy sometimes used for "base plates." It is also alloyed with *platinum* for the same purpose.

Copper.—(Sym., Cu.; At. wt., 31·7).—One of the metals most anciently known. It was named from the island of Cyprus, where it was most extensively mined and smelted by the Greeks. It has a reddish brown colour inclining to yellow, a faint but nauseous and disagreeable taste, and when rubbed between the fingers imparts a smell somewhat analagous to its taste. Its specific gravity is from 8·8 to 8·9. It is much more malleable than ductile, so that far finer leaves may be obtained from it

* Ure.

than wire. Its melting point is stated to be 1,996° Fah.; at a higher temperature it evaporates in fumes which tinge flame a bluish green. By exposure to heat with access of air, it is rapidly converted into black scales of protoxide. In tenacity it yields to iron, but considerably surpasses gold, silver, and platinum in this respect.

Aluminium.—(Sym., Al.; At. wt., 13·7).—This metal is extremely light, its specific gravity being only 2·56; thus gold is more than seven times, and platinum more than eight times, heavier. Its colour is white, but with a bluish tinge resembling lead, and its fusing point is between the melting points of zinc and silver. It is not acted upon by cold nitric acid, very slightly attacked by dilute sulphuric, but readily dissolved by hydrochloric acid with evolution of hydrogen.

Alloys of Aluminium.—Very small quantities of other metals suffice to destroy the malleability and ductility of aluminium. With 1-20th of iron or copper it cannot be worked, and 1-10th of copper renders it as brittle as glass. Silver and gold produce brittleness in a less degree. An alloy of 5 parts of silver with 100 of aluminium is capable of being worked like the pure metal, but it is harder and therefore susceptible of a finer polish; whilst the alloy containing 10 per cent. of gold is softer, but, nevertheless, not so malleable as the pure metal. The presence of even 1-1,000th part of bismuth renders aluminium brittle in a high degree.

Copper alloyed with only 1-10th of its weight of aluminium has the colour and brilliance of gold, and is still very malleable.

Aluminium may be gilded by being dipped into a solution of the hyposulphate of gold, after it has been well cleaned by the successive use of potash, nitric acid, and water.

It is soldered with difficulty. The most successful method is to coat the aluminium with copper by the electrotype process, after which soldering can be effected in the usual way. Otherwise the soldering should be effected in the following manner. The pieces of aluminium intended to be soldered must be prepared in the same manner as objects are treated for soldering with "tin," viz. by a tinning, but this tinning must be done with the solder itself. The pieces to be soldered thus "tinned" beforehand are afterwards bound together and exposed to the flame of either a glass blowpipe or other source of heat. In order to unite the solderings, small tools of *aluminium* are used. These tools are used as little soldering instruments, and they facilitate at the same time the fusion of the solder and its adhesion to the previously prepared aluminium. Use no flux to make the solder melt. The use of the little tools is an art which the workman must acquire by practice; in fact at the moment of fusion the solderings must have the friction applied as they melt suddenly in a complete manner.

SOLDERS FOR ALUMINIUM.

	1.	2.	3.	4.
Zinc . . .	80	85	88	90
Copper . .	8	6	5	4
Aluminium .	12	9	7	6

No. 1 is most fusible. No. 4 is most preferred, particularly for smaller objects.

In making the solder, the copper is first melted, the necessary aluminium is added and stirred with an iron spatula (unpolished as it comes from the blacksmith). The zinc is then added, avoiding too much heat, as this last metal is easily oxidized and very volatile.

Zinc.—(Sym., Zn.; At. wt., 32·5).—This metal is of a bluish white colour, of considerable lustre when broken, but easily tarnished by the air; its fracture is hackly, and foliated with small facets irregularly set. It has little cohesion, and breaks in thin plates before the hammer unless it has been previously subjected to a process of lamination at the temperature of from 220° to 300° Fah., by which it becomes malleable and ductile.

The specific gravity of zinc varies from 6·9 to 7·2 according to the degree of condensation to which it has been subjected. It melts under a red heat at 773° Fah. When strongly heated with contact of air, the metal takes fire and burns with a brilliant bluish white light. The result of this combustion is the white powder "ozide of zinc."

The malleability of zinc depends in a certain degree upon the temperature at which it has been melted: when cast near the temperature of its melting point, it is more malleable than when cast at a higher temperature.

The discovery that zinc is malleable is comparatively recent, and since that time the rolling of zinc has become a manufacture of considerable importance.*

* Ure.

Reduction of Zinc by Carbon and Carbonic Oxide.—The oxide is reduced by either of these agents at a strong red heat. In order that complete reduction should be effected by carbon, it is not necessary that the oxide of zinc and solid carbonaceous matter should be intimately mixed.*

Lead.—(Sym., Pb.; At. wt., 103·572).—Lead is of a bluish grey tint; its specific gravity is 11·4, and it is the softest metal in common use. Lead is very malleable, and may be rolled into thin sheets, but its ductility is not great, and it cannot be drawn into fine wire.

When a pig of lead is heated to a certain degree bordering on its melting point, and then struck sharply with a hammer, it breaks into pieces having a remarkable columnar structure, like tin similarly treated.

When two plane and perfectly clean surfaces of lead, such as may easily be produced by cutting the metal with a sharp knife, are pressed together, they adhere with great tenacity.†

Mercury.—(Sym., Hg.; At. wt., 100).—"Mercury is often found native in globules disseminated through its ores; it occurs also combined with silver and with gold in the form of amalgams, also as iodide and chloride, and very rarely as selenide; but the most abundant ore is the sulphide, or cinnabar, from which nearly all the mercury of commerce is obtained. Its most important mines are those of Idria, in Illyria, and of Almaden, in Spain. At Almaden it is found in veins, often nearly fifty feet thick, traversing

* Percy's "Metallurgy." † Ibid.

the micaceous schists of the older transition period."

Purification from Foreign Metals. —"A small quantity of mercury may be speedily purified by placing it in a bottle with a little finely powdered loaf-sugar, the mercury not occupying more than one-fourth of the capacity of the bottle; the bottle is then closed and briskly agitated for a few minutes, after which the stopper is withdrawn, and fresh air blown into the bottle with a pair of bellows, and the agitation is repeated; this is done three or four times, and the mercury is then poured into a cone of smooth writing paper, having a pin hole at its apex. The metal then runs through, leaving the pounded sugar mixed with the oxides of the foreign metals, and a considerable quantity of finely divided mercury.

"Pure mercury should leave no residue when dissolved in nitric acid, evaporated and ignited, or when fused with sulphur and sublimed in a glass flask. When made to run down a gently inclined surface it should retain its round form, and *not drag a tail*; and when agitated in a bottle with dry air it should not yield any black powder."*

Properties.—Mercury freezes at 37·9° Fah. undergoing considerable contraction at the moment of congelation, and forming a tin-white, ductile mass, crystallized in octahedrons and needles, capable of being cut with a knife, and exhibiting a granular fracture. When heated to 662° Fah. mercury boils, and forms an invisible transparent

* Watts's "Dictionary of Chemistry."

vapour of specific gravity 6·976. The specific gravity of this metal at 60° Fah. is 13·56.

SILVER SOLDERS.

Description.	Fine Silver.	Copper.	Spelter.
Hard solder . .	16 parts	3½ parts	½ part
Medium solder. .	15 ,,	4 ,,	1 ,,
Easy common solder	14 ,,	4½ ,,	1½ ,,
Common hard . .	12½ ,,	6 ,,	1½ ,,
Common easy . .	11½ ,,	6½ ,,	2 ,,

FUSING POINTS OF ABOVE.

No. 1.	Hard solder	1,866 deg. Fah.
,, 2.	Medium solder . . .	1,843 ,,
,, 3.	Easy solder . . .	1,818 ,,
,, 4.	Common solder. . .	1,826 ,,
,, 5.	Common easy solder . .	1,802 ,,

SOFT SOLDER.

Pure grain tin	2 parts.
Pure lead	1 part.

Melt in an iron ladle, lead first, then after heating the tin over the ladle add it to the melted lead.

SOFT SOLDERING FLUID.

Spirits of salt	2 parts.
Metallic zinc	1 part.

Procure an earthen pipkin, and put into it 2½ ozs. of spirits of salts and 1 oz. of metallic zinc in small pieces. When the zinc has dissolved, or the effervescence has partially ceased, the temperature may conveniently be increased by placing the pipkin with its contents upon a sheet of iron over a gas-jet; the extra half-ounce of spirits of salts will allow for loss by evaporation. Sometimes it will be found necessary, especially when the acid is not good, to increase its temperature in order to effect its thorough saturation, for the more neutral the mixture the better it acts. The solution may be allowed to settle when sufficiently acted upon, and the supernatant liquor poured from the sediment into a bottle ready for use. This mixture will keep any length of time in a corked bottle. When this is employed in soft-soldering iron or steel, the addition to it of a small portion of powdered sal-ammoniac is a great improvement; a quarter of an ounce to the proportion of solution given above will form a very good mixture.

CHAPTER XVII.

PROPERTIES OF METALS, SPECIFIC GRAVITY, ETC.

Properties of Metals.—*Tenacity.*—The tenacity of the metals has been measured by fixing firmly in a vice one end of a bar or wire of the metal, the strength of which is to be ascertained, and attaching to the other end a convenient support for weights, which are cautiously increased until the wire breaks. Taking the tenacity of lead as 1, that of the different metals after annealing is as follows * :—

Lead	1	Silver	8·9
Cadmium	1·2	Platinum	13
Tin	1·3	Palladium	15
Gold	5·6	Copper	17
Zinc	8	Iron	26

Copper, it will be observed, resists being torn asunder with three times the power of gold.

Malleability.—Gold is the most malleable of metals; that is, it can be hammered out into the thinnest leaves—it can be beaten out so thin that one square foot weighs less than 3 grs.

* Miller's "Chemistry."

The following gives the order of malleability of the metals beginning with the most malleable :—

1. Gold.
2. Silver.
3. Copper.
4. Platinum.
5. Palladium.
6. Iron.
7. Aluminium.
8. Tin.
9. Zinc.
10. Lead.
11. Cadmium.
12. Nickel.
13. Cobalt.

Ductility.—This property of being drawn into wire is given in the following order, beginning with the most ductile :—

1. Gold.
2. Silver.
3. Platinum.
4. Iron.
5. Copper.
6. Palladium.
7. Cadmium.
8. Cobalt.
9. Nickel.
10. Aluminium.
11. Zinc.
12. Tin.
13. Lead.
14. Thallium.
15. Magnesium
16. Lithium.

EXPANSION OF METALS.

Zinc (cast)	1 in 323
Zinc (sheet)	1 in 340
Lead	1 in 351
Tin	1 in 516
Silver	1 in 524
Copper	1 in 581
Brass	1 in 584
Pure gold	1 in 682
Iron wire	1 in 1802
Palladium	1 in 1000
Platinum	1 in 1167

EXPANSION OF LIQUIDS.

Spirits of wine	expand	$\frac{1}{9}$,	that is,	9	measures	become	10
Fixed oils	,,	$\frac{1}{12}$,	,,	12	,,	,,	13
Water	,,	$\frac{1}{22\cdot76}$,	,,	22·76	,,	,,	23·76
Mercury	,,	$\frac{1}{55\cdot5}$,	,,	55·5	,,	,,	56·5

Spirits of wine is therefore six times more expansible by heat than mercury is. The difference in the heat of the seasons affects sensibly the bulk of spirits. In the height of summer spirits will measure 5 per cent. more than in the depth of winter.

Specific Gravity.—The specific gravity of a body is its weight as compared with an equal bulk of another body which is taken as the standard. For solid bodies and liquids the standard of reference is pure water at a temperature of 60° Fah.; water is stated as 1 (or 1000), so that gold, whose specific gravity is stated at 19·5, is thus exactly $19\frac{1}{2}$ times heavier than water, bulk for bulk. For gases the common standard is air, but frequently hydrogen is taken as the standard by the chemist.

Method of obtaining the Specific Gravity of Solids by the Hydrostatic Balance.—Any ordinary balance which acts accurately may be used for this operation, one pan being made shorter than the other.

When the substance is *solid, heavier than water, and insoluble in it*, it is first weighed in the usual manner, then it is suspended by means of a horse-hair attached to the lower surface of the short pan of the balance; a vessel of distilled water is so placed that the substance will hang freely in it, so as not to touch the side, and the surface of the substance should be free from air bubbles. The loss of weight sustained by the substance when thus immersed is exactly equal to its own volume of water which it has displaced. It is then necessary to place weights in the short pan until the equilibrium is restored. To calculate the specific gravity, we have

only to divide the weight in air by the loss of weight in water. Where the substance is solid, and insoluble in but *lighter* than water, it must be attached to a piece of lead (or other substance sufficiently heavy to sink it); the two are then weighed in the water as before.

To ascertain the specific gravity in such cases, the lead must be weighed first by itself in water, and then with the lighter substance attached to it in water also; subtract the latter weight from the former and to the result add the weight of the light substance in air, then divide the last weight (that of the light substance in air) by the number so obtained; the result is the specific gravity of the light substance.

Or, to state the problem in algebraic formula, only three data are required, viz.: the weight in air of the light substance $= P$; the weight in water of the piece of lead (or other heavy substance) $= P'$; and the weight in water of the light substance and the lead attached to each other $= P''$. We have then the density D by the following expression:—

$$D = \frac{P}{P' - P'' + P}$$

Specific Gravity of various Qualities of Gold, &c.

Carat.	Spec. Grav.
24	19·5
23	19·08
22	18·68
20	17·87

Carat.	Spec. Grav.
18	17·05
15	15·74
13	14·86
12	14·45
10	13·6
9	13·2
8	12·82
7	12·5
Silver, pure	10·5
Copper, pure	8·96
Composition	8·37
Spelter	7·2

By the above table, the quality of any gold plate or article may very closely be ascertained, if the gold be first weighed, and its specific gravity ascertained by means of the hydrostatic balance as described. For example, suppose we wish to know the carat value of a "strange" plate, we weigh it in water and find that its specific gravity is, say, 14·5; comparing this with the numbers in the table, we find that the plate is a fraction above 12 carat.

SPECIFIC GRAVITY OF THE METALS.

	Spec. Grav.
Platinum	21·53
Gold	19·5
Mercury	13·596
Palladium	11·8
Lead	11·36
Silver	10·53
Bismuth	9·799
Copper	8·95
Nickel	8·82
Cadmium	8·694

	Spec. Grav.
Manganese	8·013
Iron	7·844
Tin	7·292
Zinc	7·146
Antimony	6·71
Aluminium	2·67

FUSING POINTS OF GOLD AND OTHER METALS.

[The following Table is given by Gee.]

					Deg. Fah.
23	carat	gold	melts	at	2012
22		,,		,,	2009
20		,,		,,	2002
18		,,		,,	1995
15		,,		,,	1992
13		,,		,,	1990
12		,,		,,	1987
10		,,		,,	1982
9		,,		,,	1979
8		,,		,,	1973
7		,,		,,	1587

			Deg. Fah.
Mercury	melts	at	37·9
Tin	,,	,,	442
Cadmium	,,	,,	442
Bismuth	,,	,,	507
Lead	,,	,,	617
Zinc	,,	,,	773
Antimony	,,	,,	1150
Silver	,,	,,	1873
Copper	,,	,,	1996
Gold	,,	,,	2016
Cast iron	,,	,,	2786
Palladium } Platinum }	require the heat of the oxyhydrogen blowpipe.		

Thus it will be seen that while mercury remains

fluid at a temperature as low as 37·9° below the zero of Fahrenheit's scale, tin, cadmium, bismuth, lead, and zinc melt below redness;* antimony above a red heat; silver, copper, and gold require a bright cherry-red heat; iron requires a white heat; and platinum and palladium require to effect their fusion the intenser heat of the oxy-hydrogen blowpipe. Some metals near their melting points, before undergoing complete fusion, pass through a soft intermediate stage, in which, if two clean surfaces be presented to each other, and strong pressure or hammering be employed, they unite or weld together so as to form one continuous mass. Iron, thallium, lithium, and potassium afford the most striking instances of this. Palladium and platinum are also susceptible of it.

* Vide pp. 254, 255.

CHAPTER XVIII.

*ELECTRO-GILDING.**

FOR the purpose of giving to gold plates that uniformity of colour which is wanting where a considerable surface of solder exists—as is the case with flat teeth—some dentists give them a coating of fine gold by means of the "battery process."

The apparatus and materials required are a battery, a thin plate of fine gold, and a pot containing a solution of fine gold with cyanide of potassium; two copper wires proceed from the battery, the one joined to the zinc and the other to the platinum, and reach over to the vessel containing the solution, and to these extremities, which are bent to a hook shape, the fine gold and the plate to be coloured are attached. The *fine gold* is invariably attached to the wire which proceeds from the *platinum of the battery*—the positive pole; the *plate to be coloured* is invariably attached to the wire which proceeds from the *zinc*—the negative pole. The solution is heated to 150 Fah. before com-

* As many dentists adopt this practice with a *legitimate* object, we have inserted this chapter on the subject in the hope that it will enable them to obtain satisfactory results.

mencing this operation, and the gold plate, which must be carefully cleaned, should remain in a basin of pure water until all is prepared for dipping. It is then suspended upon its proper wire, and, along with the fine gold which is upon the other, immersed in the solution. Action at once commences; the effective current of electricity flowing from the zinc to the platinum, thence through the copper wire to the fine gold, and through the solution to the suspended plate upon which it deposits a layer of gold, and so passing onwards by the wire attached to the latter plate it reaches again the zinc, from which it started.

Battery.—The "Smee" battery is most convenient, and is generally employed for this purpose. A single cell arrangement (Fig. 101) consists of a sheet of platinized silver placed between, but without touching two plates of amalgamated zinc. So as to keep the zinc plates apart, a slip of varnished wood is interposed between them at their upper borders; in a groove on the under surface of this slip, or frame of wood, is secured the silver plate; all the parts are bound together by a brass binding-screw, the silver plate is prevented from touching the amalgamated zincs by pieces of cork placed between them at their lower ends.

This arrangement is then placed in a jar—glass, stoneware, or gutta-percha—containing dilute sulphuric acid (one of acid to ten of water, by measure). It is important that the sulphuric acid (oil of vitriol) should be free from nitric acid (which it sometimes contains), because that acid wastes the zinc, and in Smee's battery also corrodes the silver.

The gilding operation may be performed with the one cell. In that case the gold solution must be heated to a higher degree (200 Fah.) than when the double cell is used. The latter is commonly employed.

The battery may easily be constructed in the workroom. The following particulars will be found of service whether they be so made or whether they be purchased, as in the latter case it is still necessary to amalgamate the zincs from time to time; further, the success of the operation depends upon maintaining the apparatus and solution in good working order, and to accomplish this some acquaintance with details is necessary.

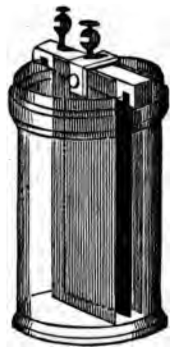


Fig. 101. Smee's Battery.

First, with regard to the platinized silver plate, which constitutes the negative *metal* (the copper wire attached to this and reaching to the solution is called the positive *pole*). The silver to be prepared for this should be of a thickness sufficient to carry the current of electricity (about the thickness of pattern lead), and should be roughened by brushing it over with a little strong nitric acid, so that a frosted appearance is obtained. It is then washed and placed in a vessel with dilute sulphuric acid, to which a few drops of nitro-muriate of platinum has been added; a porous tube is then placed into this vessel with a little dilute sulphuric acid. Into this tube a piece of zinc is put, contact being made between the zinc and silver; the

platinum will in a few seconds be drawn down upon the silver as a black metallic powder. The operation is now completed and the platinized silver ready for use. A simple method which obviates the use of a battery may be adopted. Place the silver between two pieces of sandpaper, and press it with a common smoothing-iron, then pull the silver out while under the pressure. The platinum solution is made very hot, and the silver dipped into it for some time, which effects the coating. The nitro-muriate of platinum is easily prepared. Take one part of nitric acid and two parts of hydrochloric, mix together, and add a little platinum, either as metal or sponge; keep the whole at or near boiling point; the metal is then dissolved, forming the solution required.

The zinc plates used are from 4 to 6 inches long by 4 broad, and they should be at least $\frac{1}{8}$ of an inch thick. The following is from Napier's "Electro-Metallurgy."

Zinc for Battery.—The zinc used for the battery should be *milled* or rolled zinc, not thinner than $\frac{1}{8}$ of an inch, otherwise the waste will be very great. The best thickness when their size is upwards of 4 inches square is $\frac{1}{4}$ of an inch.

Amalgamation of the Zinc Plates.—A mixture of eight parts water and one sulphuric acid is put into a stoneware basin, which should be large enough to allow the zinc plate to lie flat in it; the acid should cover the zinc plate, which must remain until the surface becomes perfectly bright. The pan is now raised on one side, and a little mercury put into the lower part, care being taken that the

zinc does not touch the mercury, to prevent which is the object of raising the pan on one side. A little coarse tow, tied to the end of a piece of wood, is dipped into the mercury, which lifts small portions of the metal mechanically, which is then rubbed with considerable pressure upon both sides of the zinc plate, over which the mercury flows easily; the plate is then washed by dipping it into clear water, and is next made to stand upon its edge in another pan with two small pieces of wood under it, so as to allow any excess of mercury to drain from it. After the zincs have drained for a few hours the process should be repeated, only it is not necessary to allow the metal to lie in the acid in the second process previous to rubbing in the mercury; after draining a few hours the second time amalgamation is completed. The zinc plates should always be removed from the battery immediately after the gilding operation is completed, and the surface carefully brushed with a *hard* hair-brush in water, and then laid by in a safe place.

If the battery is to be used seldom, and only for a short period at a time, or if the zinc is thin, another method of amalgamation may be adopted. The zinc plate, after lying in the dilute acid till the surface is bright, may be rubbed over with a solution of nitrate of mercury, which gives a very thin amalgamation; but this method is unsuitable if the battery is to be used for several hours together.

Battery Process of preparing the Gold Solution.—This is the best and cheapest method of

making up the solution; it saves all expense of acids and the labour of precipitation and washing necessary in preparing it from the chloride of gold. Say the operator wishes to prepare a gallon of gold solution, he dissolves 4 ounces of cyanide of potassium in 1 gallon of water, and heats the solution to 150 Fah.; he now takes a small porous cell and fills it with this cyanide solution, and places it inside the gallon of solution. The two solutions should be on a level. Into this cell is put a small plate of iron or copper, and attached by a wire to the zinc of a battery. A piece of gold is placed into the large solution, facing the plate in the porous cell, and attached to the copper of the battery; the whole is allowed to remain in action until the gold, which is to be taken out from time to time and weighed, has lost the quantity required in solution. The solution in the porous cell, except the action has continued a long time, will have no gold, and may be thrown away. Half an hour will suffice for a small quantity of solution. For all the operations of gilding by the cyanide solution, it must be heated to at least 130 Fah. Any convenient means may be adopted for heating the solution. Where glass or stoneware vessels are used for holding the gilding solution, these are placed in another vessel, made of tin plate or iron, of the same depth, and filled to within an inch of the mouth with water, and placed upon a hot plate over a fire, or over gas burners, and the water heated to the boiling point.

If two pairs of plates be used, the solution should be kept at about 150° Fah. while gilding; if only

one pair, the heat of the gold solution should be raised to 200° Fah.

Conditions required in Gilding.—The gilding solution generally contains one-half to an ounce of gold in the gallon; but for colouring small articles a weaker solution will do. The solution should be sufficient in quantity to entirely cover the article at once, so that it should not have to be done bit by bit. The rapidity with which metals are acted upon at the surface line of the solution is remarkable. If the positive electrode is not wholly immersed in the solution, it will in a short time be cut through at the surface of the water as if cut by a knife.

Maintaining the Gold Solution.—As the gold solution evaporates by being kept hot, distilled water must from time to time be added. This water should always be added when the operation of gilding is over for the time, not when it is about to be commenced, or the solution will not give so satisfactory a result. The average cost of depositing gold is about 2d. per dwt.

To obtain a deposit of a good colour, much depends upon the heat and state of the solution and battery. It is therefore necessary that strict attention be paid to these, and also the weight of gold deposited, and the loss sustained by the positive electrode. The plate of pure gold which is attached to the wire proceeding from the platinum of the battery should, in regard to its surface, be as near as possible equal in extent to the article to be coloured.

From time to time a little cyanide of potassium must be added to the gold solution; if the gold

pole has a film or crust upon it when withdrawn from the solution, that is a certain indication that the latter is deficient of cyanide of potassium; if the gold pole comes out clean the solution is right. Care must be taken to distinguish the crust, which is occasionally dark green or black, from a black appearance which the gold pole will take when it is very small in comparison with the article being gilt, and which is caused by the tendency to evolve gas. In this case an addition of cyanide of potassium would increase the evil. The black appearance, from the tendency to the escape of gas, has a slimy feel and look. This generally takes place when the solution is nearly exhausted of gold, of which fact this appearance, taken conjointly with the relative sizes of the electrodes, is a sure guide.

To regulate the Colour of the Gilding.—The gold upon the gilt article, on coming out of the solution, should be of a dark yellow colour, approaching to brown; this when "scratch-brushed" will yield a beautifully rich deep gold. If the colour is blackish it ought not to be finished, for it will never either brush or burnish a good colour. If the battery is too strong, and gas is given off from the article, the colour will be black; if the solution is too cold, or the battery rather weak, the gold will be light coloured. A very rich dead shade may be made by adding ammoniuret of gold to the solution just as the articles are being put in. If a bright clear yellow gilding is wanted, that will require no scratch-brushing, add to the solution a small quantity of caustic soda.

Preparation of Articles for Plating.—Articles

that are to be plated are first boiled in an alkaline ley to free them from grease, then washed from the ley and dipped into dilute nitric acid, which removes any oxide that may be formed upon the surface; they are afterwards brushed over with a hard brush and sand, of which a kind obtained from the Isle of Wight, and known as silver sand, is the best. The alkaline ley should be in a caustic state, which is easily effected by boiling the carbonated alkali and adding slaked lime, until, on the addition of a little acid to a small drop of the solution diluted with cold water, no effervescence occurs. The lime is then allowed to settle, and the clear liquid is fit for use. The ley should have about half a pound of soda-ash or pearl-ash to the gallon of water. The nitric acid, into which the article is dipped, may be diluted to such an extent that it will merely act upon the metal. Any old waste acid used for dipping before plating will do for this purpose. The article, being thoroughly cleaned and dried, is weighed, and a copper wire attached to it, either by twisting it round the article or putting it through any open part of it to maintain it in suspension. It is then dipped into strong nitric acid as quickly as possible, washed through water, and then immersed in the gold solution, suspending it from the wire connected with the zinc of the battery. This first immersion should only be continued long enough to impart a blush of gold; the article is then taken out and again brushed and put back into the solution, and kept there for three or four minutes, which will be sufficient if the solution and battery

are in good condition; but the length of time necessarily depends on these two conditions, which must be studied and regulated by the operator.

When taken from the solution the article, if it is not wanted to have a *dead* surface, is brushed with a hard hair-brush and old ale, beer, or water containing in solution a little gum, glue, or sugar.

Roseleur says, "I do not hesitate to state that, even with very inferior electro-plating solution, good results may be arrived at if the *cleansing* is perfect, while the converse cannot be maintained."

Such is the method employed where electro-plating is carried on upon a large scale, and it shows how important it is to have the articles in a perfect state of cleanliness before immersing them in the solution in order to obtain good results. Dentists seldom put the work through all these preparations, however, and simply wash the plate thoroughly after polishing at the wheel, and leave it in a basin of pure water until ready to immerse it in the solution.

Glass hooks should be used for manipulating with. They are very easily made by heating and bending a glass rod over the bunsen flame into a convenient shape, one end being turned back upon itself to form the handle, and the other bent to a hook shape. These are used if the plate should happen to fall into the solution.

CHAPTER XIX.

MISCELLANEA.

THERMOMETERS, TEMPERING, ETC.

THE scale according to Fahrenheit is the one generally adopted in England for registering degrees of temperature; but the Centigrade thermometer is preferred by scientists. The scales of Reamur and De Lisle are not so generally used as the two former.

The boiling point of water is represented on the Fahrenheit scale as 212°; on the Centigrade as 100°; and on the Reamur as 80°. To change Fahrenheit to Centigrade, subtract 32 from the Fahrenheit degrees, multiply the answer by 5, and divide the product by 9; the result gives the degrees Centigrade. For example, convert 212° Fahrenheit into Centigrade: 32 from 212 gives 180, this multiplied by 5 gives 900, which divided by 9 becomes 100 = the degrees Centigrade, corresponding to 212° Fahrenheit.

To convert Centigrade to Fahrenheit, multiply the degrees Centigrade by 9, divide the product by 5, and add 32 to the quotient; the result gives the degrees Fahrenheit.

The method of converting the degrees of one scale into others is thus stated:—

To convert Fah. to Cent. $\frac{5}{9}(F.^\circ - 32) = C.^\circ$
" " Cent. to Fah. $\frac{9}{5}\ C.^\circ + 32 = F.^\circ$
" " Reamur to Fah. $\frac{9}{4}\ R.^\circ + 32 = F.^\circ$
" " Fah. to Reamur $\frac{4}{9}(F.^\circ - 32) = R.^\circ$

The following table represents the corresponding temperature of Fahrenheit and Centigrade below boiling point.

TABLE OF CORRESPONDING TEMPERATURES ON THE SCALES OF FAHRENHEIT AND CENTIGRADE THERMOMETERS.

Deg. Cent.	Deg. Fah.	Deg. Cent.	Deg. Fah.	Deg. Cent.	Deg. Fah.
100	212	66	150·8	32	89·6
99	210·2	65	149	31	87·8
98	208·4	64	147·2	30	86
97	206·6	63	145·4	29	84·2
96	204·8	62	143·6	28	82·4
95	203	61	141·8	27	80·6
94	201·2	60	140	26	78·8
93	199·4	59	138·2	25	77
92	197·6	58	136·4	24	75·2
91	195·8	57	134·6	23	73·4
90	194	56	132·8	22	71·6
89	192·2	55	131	21	69·8
88	190·4	54	129·2	20	68
87	188·6	53	127·4	19	66·2
86	186·8	52	125·6	18	64·4
85	185	51	123·8	17	62·6
84	183·2	50	122	16	60·8
83	181·4	49	120·2	15	59
82	179·6	48	118·4	14	57·2
81	177·8	47	116·6	13	55·4
80	176	46	114·8	12	53·6
79	174·2	45	113	11	51·8
78	172·4	44	111·2	10	50
77	170·6	43	109·4	9	48·2
76	168·8	42	107·6	8	46·4
75	167	41	105·8	7	44·6
74	165·2	40	104	6	42·8
73	163·4	39	102·2	5	41
72	161·6	38	100·4	4	39·2
71	159·8	37	98·6	3	37·4
70	158	36	96·8	2	35·6
69	156·2	35	95	1	33·8
68	154·4	34	93·2	0	32
67	152·6	33	91·4		

The Tempering of Instruments and Tools.—As many are in the habit of reshaping and tempering their own excavators, &c., and all may occasionally find it necessary to adapt an instrument for special circumstances, the following remarks upon tempering may be of value.

Before the instrument can be filed or bent into shape, its temper must be taken out; this is done by heating it to a red heat. But it must be remembered that *over-heating* destroys the steel and permanently deprives it of its essential qualities. An instrument heated to a white heat, for example, cannot subsequently be satisfactorily tempered, and may indeed be considered altogether useless. Therefore it is most important to remember that in heating to extract the "temper" of the instrument or tool that is to be reshaped, only a dull red should be given to the metal; it is then allowed to cool in air, when it may be worked upon. After being shaped, fine filed, and smoothed, the instrument is next heated in the flame to a cherry red, and instantly plunged into cold water. This operation leaves the steel too hard for our purpose, so that it is necessary to "draw" the temper to the required amount. This is done by very carefully heating the instrument more or less according to the work it is designed for. The *point* is first brightened by rubbing it on sand-paper, so that the colours which the heat imparts to the steel may be clearly observed. A pale straw colour is the one allowed for excavators; when that is reached the instrument is at once withdrawn from the flame. Or the following method may be adopted.

"For excavating instruments cover with oil and hold over the alcohol lamp, apply the heat to the instrument a little back from the point, and move it backwards and forwards in the flame so as to heat it up slowly and uniformly, and at the instant the oil takes fire at the point of the instrument it should be plunged into cold water."

Tempering Liquid.—2 quarts soft rain water, ⅓ oz. corrosive sublimate, 1 oz. common salt.

Tempering Drills and Gravers.—When the graver or drill is too hard—which may be known by the frequent breaking of the point—temper as follows: heat a poker red hot and hold the graver to it within an inch of the point, waving it to and fro till the steel changes to a light straw colour; then put the point into oil to cool.

Steel alloyed with 1-500th part of platinum is rendered harder, more malleable, and better adapted for cutting instruments.

Pouillet has employed an air thermometer provided with a bulb of platinum to determine with precision high degrees of temperature.*

RESULTS.

	Fah. Deg.	Cent. Deg.
Incipient red heat corresponds to	977	525
Dull ,, ,,	1292	700
Incipient cherry red ,,	1472	800
Cherry red ,,	1652	900
Clear cherry red ,,	1832	1000

* Percy's "Metallurgy."

	Fah. Deg.	Cent. Deg.
Deep orange corresponds to	2012	1100
Clear ,, ,,	2192	1200
White ,,	2372	1300
Bright white ,,	2552	1400
Dazzling ,,	2732 to 2912	1500 to 1600

Table for Tempering.

	Fah. Deg.	
1. Very pale straw yellow	430	Tools for metal excavators, &c.
2. Shade of darker ,,	450	
3. Darker straw	470	Tools for wood, screw taps, &c.
4. Still darker straw	490	
5. Brown	500	Hatchets, chipping, and other percussion tools, saws, &c.
6. Yellow tinged slightly with purple	520	
7. Light purple	530	
8. Dark ,,	550	Springs.
9. Dark blue	570	
10. Paler ,,	590	
11. Still paler blue	610	Too soft for above purposes.
12. ,, ,, tinge of green	630	

Table of Useful Numerical Data.*

1 centimetre	=	·3937 inches.
1 decimetre	=	3·937 ,,
1 metre	=	39·37 ,,
1 gramme	=	15·432 grains.
1 kilogramme	=	15432 ,,
1 ,,	=	35·274 ounces, avoirdupois.
1 ,,	=	2·2046 pounds ,,
1 ounce avoirdupois	=	437·5 grains.
1 pound ,,	=	7000 ,,

* "Electro-Metallurgy" (Gore).

1 pennyweight troy . . .	=	24 grains.
1 ounce ,, . . .	=	480 ,,
1 pound ,, . . .	=	5760 ,,
1 litre of water . . .	=	15432 ,,
1 ,, . . .	=	1000 grammes.
1 ,, . . .	=	35 ounces by measure.
1 gallon of water . . .	=	4·536 litres.
1 ,, . . .	=	70000 grains.
1 cubic inch of water . . .	=	252·5 ,,
1 ounce measure	=	1·733 cubic inches.
1 pint (or 20 ounces) . . .	=	34·659 ,,
1 gallon (or 160 ounces) . .	=	277·276 ,,
1 litre	=	61·024 ,,

At the ordinary temperature and pressure of the atmosphere 100 cubic inches of—

		grs.			grs.
Hydrogen	weigh	2·11	Oxygen	weigh	33·80
Ammonia	,,	18·00	Carbonic anhydride	,,	46·50
Hydrocyanic acid	,,		Sulphurous ,,	,,	67·78
Vapour	,,	28·57	Chlorine	,,	76·40
Nitrogen	,,	29·70	Sulphuretted hydrogen	,,	80·50
Atmospheric air	,,	31·00			

Soldering on Casting Sand instead of Plaster.— "A handful of light moist sand, just in a state to cast with, is deposited in the hollow of the casting coke. The two pieces of gold to be soldered together are placed upon it, having been previously stuck together in their relative position, as previously spoken of. They are gently pressed into the sand so as to be supported underneath, everywhere steadily, care being taken not to disturb their relative positions. The sand is pressed down around them so as not to be blowing loosely about when the blowpipe is used, and none is allowed to

remain on the upper surface. The flame is now at once applied with the blowpipe until all the cement has disappeared. With a very light hand place a piece of No. 1 solder on the most convenient part of the joint, but put no borax. This must now be run with the blowpipe so as to hitch the two together. If borax were used it would shift the pieces in rising when heated, sand not being strong enough to resist it. This is the point in soldering in sand which requires more care than soldering in plaster. It is soon learned, and the advantage in time and cleanliness only needs trial to be appreciated. After hitching one point with solder, borax may be freely applied, and the soldering completed. This method can be used in almost all cases where two pieces of gold have to be joined in exact relative positions, such as mounting clasps, &c.; but not in putting up flatbacks, as it is not convenient for the gradual heating they require."—(Mr. Balkwill, *B. J. D. S.*, May, 1876.)

Where this plan is adopted, only new sand, which has not yet been used for casting, should be employed; the sand in use contains particles of zinc and lead, which when heated with it will destroy the gold plate.

Packing the Vulcanite Regulating Pieces without using Wax Plates.—This plan, suggested by Mr. Caleb Williams, is further referred to by Mr. Balkwill in the *British Journal of Dental Science* for January, 1876. He says, "The plaster model is not dipped in wax but dried, and, whilst warm, coated by a camel's-hair pencil with a chloroform solution of uncooked rubber. I generally use the

'whalebone.' This coat is laid on while the model is warm to promote the evaporation of the chloroform, which makes the rubber spongy if any remains. The solution should be carried wherever the plate is intended to go.

"A pattern in sheet lead having been previously prepared, a plate is cut by it out of the soft rubber, which is placed upon the model and carefully pressed with the forefinger into all the inequalities of the impression. The rubber will be found to adhere to the previous coating with the greatest tenacity, therefore a little care is necessary in placing in position, as after touching the model it cannot be shifted. This can be done by doubling the pattern over the right forefinger and placing this on the middle of the palate; the two wings can then be brought down and gently pressed into place. Any part that requires strengthening or thickening to carry plugs, &c., must have rubber added, just as in the ordinary method wax is built upon a wax core. The piece is now smothered in plaster, placed in a flask, filled up, and, when the plaster is set, vulcanized. The process up to the vulcanizing occupies from five to ten minutes instead of one or two hours. There is no straining of the model in any way, the fit is exact, and slender teeth and undercuts, which, to say the least, make a difficulty ordinarily, are thus fitted with ease."

Acids, &c., used in the Workroom.—In the textbook of "Electro-Metallurgy," by Gore, the following remarks are made with regard to acids.

Nitric Acid.—Called also aqua-fortis. The pure

acid for dissolving silver, &c., should be colourless, have a specific gravity of not less than 1·52, and separate portions of it, diluted with pure distilled water, should give no cloud with a single drop of solution of nitrate of silver or of chloride of barium. It should be kept in a stoppered bottle, in a dark, cool, and dry place. If a drop of this or any other acid falls upon one's clothes, *diluted* aqueous ammonia should at once be freely applied.

All the pure strong acids should be kept in stoppered bottles in a dry place. Carboys of common acids and dripping liquids should have stoneware stoppers, and be kept in an outhouse.

Hydrofluoric Acid.—Called also fluoric acid. This liquid is always very impure. It should be kept in a bottle of gutta-percha, provided with a stopper of india-rubber, in a dry and cool place, and not in close proximity to glass vessels, because the vapour corrodes them. It is highly dangerous to breathe the fumes of this acid; and if a drop of it falls upon the skin it should be *thoroughly* washed off *at once*, otherwise after a few hours great pain will be suffered.

Hydrochloric Acid.—Called also "muriatic acid," "spirits of salt," and "smoking salts." The pure acid should be colourless, of not less specific gravity than 1·20. It should be kept in a cool place.

Aqua Regia.—Called also nitro-hydrochloric acid. This is a mixture of one volume of nitric and from two to three of hydrochloric acid. It should not be prepared until required to be used, because it decomposes spontaneously.

Sulphuric Acid.—Or "Oil of Vitriol." The pure acid should have a specific gravity of not less than 1·85, and be nearly or quite colourless. The least trace of dust or organic matter imparts a darkness of appearance to it. It should be kept in a dry place. When diluting it, the water should not be poured into the acid, because that is dangerous, but the acid into the water, and that slowly.

Bisulphide of Carbon.—Called also "sulphuret of carbon" and "carbon disulphide." This is a very volatile and inflammable liquid, and a flame should not therefore be brought near its vapour. It should be kept in a well-stoppered or corked bottle in a cool place.

Phosphorus.—This substance should be kept in a wide-mouthed stoppered bottle, filled with water, to keep the air from contact with it. The bottle should also be covered with black varnish, and kept in a dark place, because the light changes the phosphorus and makes it insoluble. Phosphorus should never be exposed to the air for more than a few seconds, or it may inflame; and it should always be cut whilst under the surface of water.

Phosphorus Solution.—Called also "Greek fire." This highly inflammable and dangerous mixture is composed of phosphorus dissolved in bisulphide of carbon. It should only be prepared in small quantity; and the bottle containing it should be kept in a cool place, partly immersed in sand, in a stone-ware vessel covered with a metal lid. It is extremely liable to spontaneous combustion, especially if any be spilt.

Aqueous Ammonia.—Called also "volatile alkali,"

"spirit of hartshorn," &c. This liquid is very volatile, and should be kept in well-stoppered bottles in a very cool place. Its specific gravity should not be greater than ·880. It is dangerous to break the bottles.

Carbonate of Ammonia.—Called also "smelling salts" and "sal volatile." The unchanged substance is in the form of *transparent* colourless pieces. By exposure to air it loses ammonia, and becomes opaque white. It should therefore be kept in well-closed bottles.

Hydrocyanic Acid.—Called also "prussic acid." This is a colourless liquid consisting of water more or less impregnated with the gas. Water will dissolve a very large amount of the gas. The strongest usually sold is known as Scheele's, and contains about 5 per cent. of the actual substance; the ordinary medicinal acid contains only 2 per cent. It is extremely poisonous, and dangerous to smell or inhale the vapour arising from it. It is decomposed by light, and should therefore be kept in an opaque bottle, in a dark and cool place.

Cyanide of Potassium.—Called also "prussiate of potash." This substance also is a deadly poison and almost as dangerous when absorbed by the skin as when swallowed. It is strongly alkaline and abstracts moisture rapidly, and should therefore be kept in well-covered jars or bottles.

Filters.—Small ones for filtering dilute acids or alkalies, and liquids generally, are made by doubling a circular sheet of filtering paper (*i.e.* unsized or blotting-paper) twice at right angles, opening one of the outer folds, and placing the filter in a

glass funnel. Large ones are usually formed by tying or nailing the edges of a piece of washed or unglazed calico to those of a square frame of wood or of a wooden hoop. A filter for strong acids or alkalies is made by placing a loose plug of asbestos in the neck of a glass funnel, or by filling the neck of the vessel with broken glass, and covering the latter with a layer of asbestos.

Remedies for Accidents.—The following, which is also quoted from Gore's work, may be found useful in the workroom.

"As various poisonous substances are employed in the art, it would be well for the operator to know their best antidotes. If either nitric, hydrochloric, or sulphuric acid have been swallowed, the best remedies are either to administer abundance of tepid water to act as an emetic, or to cause the patient to swallow milk, the whites of eggs, some calcined magnesia, or a mixture of chalk and water. If those acids in a concentrated state have been spilled upon the skin, the parts should be washed with plenty of cold water, and if necessary a mixture of whiting and olive-oil then applied. A useful mixture for such cases is formed by slaking about an ounce of caustic lime with a quarter of an ounce of water, then adding it to a quart of water and shaking the mixture repeatedly; decanting the clear liquid, and beating it up with olive-oil to form a thin pomatum. Acids spilled upon the clothes should at once be treated with plenty of a quite dilute solution of ammonia or its carbonate, and then well washed with water.

"In cases where hydrocyanic acid, cyanide of potassium, or the ordinary silvering or gilding solutions have been swallowed, almost instant death usually follows; if it does not, *very cold* water should be allowed to run upon the head and spine of the sufferer, and the patient be made to swallow a dilute solution of either acetate, citrate, or tartrate of iron. If the poisoning arises from inhaling the vapour of hydrocyanic acid, cold water should be applied as above, and the patient be caused to inhale atmospheric air containing a *little* chlorine gas. It is a dangerous practice to dip the naked hands or arms in cyanide solutions, as workmen sometimes do, in order to recover articles which have fallen into them, because those liquids are absorbed by the skin, and produce poisonous effects; they also cause very painful sores, which should be well washed with water, and the mixture of lime-water and olive-oil applied. If alkalies such as potash or soda have been swallowed, a dilute solution of vinegar, some lemonade, or extremely dilute sulphuric acid, should be given, and, after about ten minutes, a few spoonfuls of olive-oil.

"If metallic salts have been taken, the patient should be made to vomit by means of tepid water, and then to swallow some milk, whites of eggs, precipitated sulphur, or some sulphuretted hydrogen water. To remove stains of sulphate of copper, or of salts of mercury, silver, or gold from the hands, &c., wash them first with a dilute solution either of ammonia, iodide, bromide, or cyanide of potassium, and then with plenty of water; if the stains are old ones, they should first be rubbed

with the strongest acetic acid, and then treated as above.

"Grease, oil, pitch, or tar may usually be removed from the hands, clothes, &c., by rubbing with a rag saturated with benzine, spirits of turpentine, or bisulphide of carbon."

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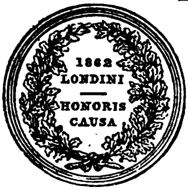

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